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The Neuropsychological Application of the WAIS-IV over the WAIS-III

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The Neuropsychological Application of the WAIS-IV over the WAIS-III

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ABSTRACT

The Neuropsychological Application of the WAIS-IV over the WAIS-III

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The current study examined the WAIS-IV and how the changes to the test may impact the measure's usefulness in neuropsychological evaluations. It was hypothesized that the WAIS-IV would be a significantly better predictor of performance on the neuropsychological measures of the Category Test, Finger Tapping Test, Trail Making Test, and Wisconsin Card Sorting Test over the WAIS-III. The mixed clinical sample came from an archival database of volunteer research participants and individuals clinically referred to a university outpatient facility. A total of 91 participants were administered the WAIS-III and WAIS-IV as part of a larger neuropsychological battery.

The results of the current study found that both the WAIS-III and the WAIS-IV were able to account for a significant amount of the variance in performance on the neuropsychological measures, with the exception of the FTT dominant and non-dominant hands, where only the WAIS-IV was able to significantly account for the variance in performance on the measures. Using the Alf and Graf (1999) model, there were no significant R^2 differences between the WAIS-III subtests and WAIS-IV at the .01 significance level. Thus, the WAIS-IV did not provide a better model for predicting performance on any of the neuropsychological measures. It should be noted that the small sample size of the current study may have inflated the R^2, particularly in the WAIS-III models, which could have masked greater R^2 differences between the two models.

While the publishers endeavored to make the WAIS-IV a better measure of processing speed, working memory, and fluid reasoning, these goals were largely unmet. The analyses of the WAIS-IV working memory subtests, showed that the sequencing component added to the Digit Span subtest did not add to the relationship with neuropsychological measures with working memory components. The analyses of the WAIS-IV processing speed subtests showed that the Coding subtest of the WAIS-IV was a better measure of processing speed than the WAIS-III version, but this was not found for the PSI as a whole. Changes to Symbol Search did not show any improvement in the relationship to neuropsychological measures.

One interesting finding was that the new subtest of Visual Puzzles does appear to add to the relationship with neuropsychological measures over the other subtests of the WAIS-IV. Visual Puzzles was consistently the highest correlated PRI subtest with the neuropsychological measures, with the exception of the WCST. The subtest appears to assess a wide range of abilities outside of the spatial reasoning skills purported by the test publishers. Specifically, the subtest was correlated with measures of processing speed, executive skills, and motor speed/reaction time. Thus, clinicians should use caution and examine all possible options when evaluating poor performance on this new subtest.

Since none of the WAIS-IV models were able to significantly predict performance on any of the neuropsychological measures over the WAIS-III models, it would appear that the WAIS-IV as a whole is not a better neuropsychological measure than its predecessor. Despite being the gold standard for intellectual assessment, the WAIS-IV appears to add little to clinical utility over the WAIS-III outside of shorter administrative time. Clinicians are advised to continue using neuropsychological measures to assess processing speed, working memory, and higher order cognitive skills in conjunction with the WAIS.

CHAPTER I

Statement of the Problem

The Wechsler Adult Intelligence Scale-Fourth Edition (WAIS-IV) is the most recent version of the Wechsler Adult Intelligence Scale. The history of the scale dates back to 1955 when David Wechsler published the first version of the WAIS as a revision to the Wechsler-Bellevue Intelligence Scale, which was published in 1939 (Sattler, 2008). The second version of the WAIS, the Wechsler Adult Intelligence Scale-Revised (WAIS-R), was published in 1981. Instead of aligning with theories of cognitive ability, these early versions of the test stayed consistent with previous versions; recent revisions to the WAIS have seen an increased effort to be aligned with current research and theoretical advances (Benson, Hulac, & Kranzler, 2010). Research conducted comparing the relationship of the WAIS-R with neuropsychological measures has indicated that the abilities assessed by the WAIS-R were consistent with those measured by neuropsychological tests (Johnstone, Holland, & Hewett, 1997; Golden, Kushner, Lee, & McMorrow, 1998).

The Wechsler Adult Intelligence Scale-Third Edition (WAIS-III) was published in 1997 and included a Verbal IQ (VIQ), Performance IQ (PIQ), and Full Scale IQ (FSIQ). New subtests were added to the WAIS-III (Devaraju-Backhaus, Espe-Pfeifer, Mahrou, & Golden, 2001), and four secondary indices could be obtained on the WAIS-III (Sattler, 2008). Much research has been conducted examining and supporting the relationship between neuropsychological measures and the WAIS-III (Titus, Retzlaff, & Dean, 2002; Sherman, Strauss, Spellacy, & Hunter, 1995; Sanchez-Cubillo et al., 2009).

The newest version of the test, the WAIS-IV, was published in 2008. With the fourth edition of the test, the designers attempted to make the test more consistent with current research and theories (Benson et al., 2010). Specifically, the latest version departs from the three traditional scores of VIQ, PIQ, and FSIQ. While the FSIQ is still derived from the scores on each subtest, instead of a VIQ and PIQ, the four index scores obtained as secondary scores on the WAIS-III are the primary scores obtained with the WAIS-IV (Gregoire, Coalson, & Zhu, 2011). The four index scores of the WAIS-IV are considered more consistent with current theories regarding the multi-factor model of intelligence. Changes in subtests were made to the new version of the WAIS and subtests were added. The revisions to and additions of subtests were designed to make the WAIS-IV a better measure of fluid reasoning, processing speed, and working memory (Lichtenberger & Kaufman, 2013). With the changes to the WAIS-IV, it is yet to be seen if these modifications have increased the clinical utility for neuropsychological evaluations. The current study was designed to examine the WAIS-IV and how the changes to the new version may impact the test's usefulness in neuropsychological evaluations.

CHAPTER II

Review of the Literature

In order to understand the relevance of the proposed investigation, it is necessary to present an examination of the Wechsler Adult Intelligence Scales and the relationship between the Wechsler Adult Intelligence Scales and neuropsychological measures.

Wechsler Adult Intelligence Scales

The WAIS has evolved into one of the most commonly used intelligence scales (Johnstone et al., 1997). The original version of the WAIS was published in 1955 by David Wechsler as a revision to the Wechsler-Bellevue Intelligence Scale published in 1939 (Sattler, 2008). The second version of the WAIS, the WAIS-R, was published in 1981 and included verbal subtests of Information, Comprehension, Arithmetic, Digit Span, Similarities, and Vocabulary. Picture Arrangement, Picture Completion, Block Design, Object Assembly, and Digit Symbol made up the performance subtests (Johnstone et al., 1997). The WAIS-R yielded a Verbal IQ, Performance IQ, and Full Scale IQ (Zarantonello, 1988). Additionally, Berger (1998) stated that the WAIS-R can be conceptualized as a three-factor test with each factor providing information about cognitive functioning. The three-factor conceptualization of the WAIS-R included the Verbal Comprehension, Perceptual Organizational, and the Freedom from Distractibility factors. The Verbal Comprehension factor consisted of the subtests of Vocabulary, Information, Comprehension, and Similarities. The Perceptual Organizational factor consisted of the subtests of Block Design, Object Assembly, Picture Completion, and Picture Arrangement. The Freedom From Distractibility factor consisted of the subtests of Arithmetic and Digit Span (Berger, 1998). While early versions of the test were more consistent with previous editions of the test as opposed to aligning with theories of cognitive ability, recent revisions to the WAIS have been more consistent with current research and theoretical advances (Benson et al., 2010).

The third version of the test, the WAIS-III, was published in 1997 and included a Verbal IQ (VIQ), Performance IQ (PIQ), and Full Scale IQ (FSIQ). Letter-Number Sequencing, Matrix Reasoning, and Digit Symbol Coding were new subtests added to the WAIS-III (Devaraju-Backhaus et al., 2001). Four secondary indices could be obtained on the WAIS-III. The Verbal Comprehension Index (VCI) consisted of Vocabulary, Similarities, Information, and Comprehension. The Perceptual Organization Index (POI) was comprised of Picture Completion, Block Design, and Matrix Reasoning. Digit Symbol-Coding and Symbol Search made up the Processing Speed Index (PSI). The Working Memory Index consisted of Arithmetic, Digit Span, and Letter-Number Sequencing (Sattler, 2008).

The Wechsler Adult Intelligence Scale-Fourth Edition (WAIS-IV) is the most recent version of the WAIS and was published in 2008. With the new version of the test, the publishers aimed to make the test a better measure of fluid reasoning, processing speed, and working memory, while making the test more consistent with current theories of intelligence. The publishers sought to decrease the speeded demands of the subtests as well as the motor demands (Coalson, Raiford, Saklofske, & Weiss, 2010).

Canivez and Watkins (2010a) and Canivez and Watkins (2010b) conducted factor analyses of the WAIS-IV with an adolescent and adult sample and found the test to be a strong measurement of general intelligence for adolescents and adults. Gottfredson and Saklofske (2009) discussed the psychological utility and application of intelligence tests and stated that the WAIS-IV further expanded on theoretical foundations and clinical utility over the WAIS-III. Further, Gottfredson and Saklofske (2009) explained that the newer WAIS-IV and the standardization studies used in its development provided a stronger empirical foundation for the clinical utility of the test. According to Hartman (2009), the WAIS-IV was designed to be an improvement from the WAIS-III in terms of developmental appropriateness (i.e., more useable for individuals with nonintellectual limitations), user friendliness, and clinical utility. The changes included clearer instructions, decreased time bonuses, and fewer motor demands (Hartman, 2009).

Benson et al. (2010) examined the WAIS-IV and what the test measures. The researchers found that some Cattell-Horn-Carroll (CHC) abilities were measured more thoroughly by the WAIS-IV. The results indicate that the CHC structures can be used to describe abilities measured by the WAIS-IV and included crystallized intelligence, fluid reasoning, visual processing, short-term memory, and processing speed. Specifically, the results indicated that Similarities, Vocabulary, Information, and Comprehension assess crystallized abilities. The PRI was shown to measure fluid reasoning and visual processing. Block Design, Visual Puzzles, and Picture Completion assessed visual processing. Matrix Reasoning, Figure Weights, and Arithmetic assessed fluid reasoning. Arithmetic, Digit Span, and Letter-Number Sequencing were shown to measure short-term memory. Symbol Search, Coding, and Cancellation were shown to examine processing speed. Figure Weights and Arithmetic were shown to evaluate Quantitative Reasoning.

Taub and Benson (2013) examined the goals of the publishers of the WAIS-IV to see if the test was a better measure than the WAIS-III. Specifically, the authors examined the fit of the standardization data from the WAIS-III and WAIS-IV to assess which test fit the publisher's measurement and scoring model best as well as which measure best fit the Cattell-Horn-Carroll model. The authors addressed how the scores achieved on the WAIS-III compared to the scores achieved on the WAIS-IV and if the scores assess the same abilities across measures. Finally, the authors sought to see if the publishers of the WAIS-IV achieved the stated goals of making the measure a better assessment of fluid reasoning, processing speed, and working memory. The authors' findings showed that the WAIS-IV provided a better fit to the instrument's standardization data when compared to the WAIS-III models. Thus, the authors concluded that the WAIS-IV provides a better theoretical measurement of intelligence than the WAIS-III. The analyses examining the two versions of the WAIS and the Cattell-Horn-Carroll model were unable to be completed because the models were unidentified. From the other analyses, the authors were able to conclude that FSIQ scores obtained by the WAIS-IV and the WAIS-III were not equivalent and should not be directly compared to one another, as the constructs were different across the overall test. Finally, the research showed that processing speed was better represented and more reliable and valid as measured by the WAIS-IV than the WAIS-III. Working memory was shown to be better measured by the WAIS-IV. In contrast, fluid reasoning was not better measured by the WAIS-IV. Taub and Benson (2013) concluded that the WAIS-IV was a technological improvement over the WAIS-III.

According to Loring and Bauer (2010), research has shown that the VIQ and PIQ of the previous versions of the WAIS were not uniform measures of verbal and nonverbal abilities. Research indicates that the VIQ assessed not only verbal abilities and knowledge, but included the subtest of Digit Span, a measure of attention and working memory. The PIQ has been shown to assess visual spatial problem solving skills, but contained subtests that assessed processing speed (Loring & Bauer, 2010). Evaluations of the previous versions of the WAIS have shown that the subtests that make up the VIQ and PIQ cluster into four cognitive domains (i.e., Verbal Comprehension, Perceptual Reasoning, Working Memory, and Processing Speed). Studies with earlier versions of the WAIS supported the four-factor structure and resulted in the factor-based composite scores that were introduced as supplemental to the VIQ and PIQ scores of the WAIS-III (Loring & Bauer, 2010).

In the development and release of the WAIS-IV, the VIQ and PIQ scores were eliminated based on research supporting the composite scales. The WAIS-IV provides four indices that make up Full Scale IQ (FSIQ) and coincide more with the theoretical framework of multiple factors making up intelligence rather than the two factors that made up FSIQ on the earlier versions of the WAIS. Loring and Bauer (2010) discussed the trend away from global IQ scores to composite scores as with the WAIS-IV and described index scores or composite scores as a more useful way to assess differential diagnoses. Hartman (2009) stated that the VCI and PRI were more conceptually accurate than the VIQ and PIQ.

The WAIS-IV includes changes to some and the elimination of other subtests along with three new subtests. The WAIS-IV, with only 10 core subtests, is significantly shorter than the WAIS-III, with 13 subtests (Hartman, 2009). The new core subtest of Visual Puzzles is part of the PRI. Hartman (2009) described the new Visual Puzzles subtest as requiring the individual to select components of an abstract puzzle figure from a set of designs shown under the figure. Figure Weights, a new supplemental test added to the WAIS-IV, was said to be an assessment of fluid reasoning and involves the individual looking at a scale containing geometric figures on two plates. One scale is missing an item and the individual is told to choose the answer that would balance the scale (Hartman, 2009). Additionally, a Cancellation subtest, similar to that seen on the WISC-IV was added as a supplemental subtest.

According to Loring and Bauer (2010), the emphasis on speeded responses has been decreased on the WAIS-IV by the elimination of bonus points based on time. Hartman (2009) stated that the rational for omitting Object Assembly and Picture Arrangement from the WAIS-IV was to decrease the motor demand required to complete the assessment and to reduce time bonus points. Loring and Bauer (2010) went on to state that, because psychomotor slowing is considered a central feature of various brain injuries, this may decrease the number of individuals in neurologic populations obtaining a FSIQ below 70 on the WAIS-IV. Thus, there may be a decrease in the number of individuals in this group who qualify for services using the FSIQ cutoff criteria of 70. Because of these changes, it was suggested that the FSIQ on the WAIS-IV has the same overall implications as the FSIQ from earlier versions of the WAIS but may have a different meaning, which may alter the WAIS-IV FSIQ in relation to its sensitivity to neuropsychological impairment. Loring and Bauer (2010) stressed the need for research examining how the modified and new subtests of the WAIS-IV are impacted by neurologic conditions.

Wechsler Adult Intelligence Scales and Neuropsychological Measures

It was hypothesized that the more recent versions of the WAIS were more consistent with theory and research and have been more useful clinically than their predecessors (Gottfredson & Saklofske, 2009). Recent research has examined the relationship between the new subtest of Visual Puzzles and neuropsychological measures. Fallows and Hilsabeck (2012) examined the Visual Puzzles subtest to assess the cognitive functions tapped by the subtest. The subtest was moderately correlated with Trail Making Test (TMT) Parts A and B (Trails A; Trails B) but not the Wisconsin Card Sorting Test (WCST) perseverative errors. Overall, the authors found that Visual Puzzles had significant correlations with neuropsychological measures of learning and recall, cognitive flexibility, visuospatial reasoning, processing speed, and naming. Thus, the authors concluded that Visual Puzzles assessed a broader range of abilities than proposed by the publisher as well as broader abilities than those assessed by Matrix Reasoning and Block Design.

While little other research is currently available regarding the current version of the WAIS and performance with neuropsychological measures, even earlier versions of the WAIS have been shown to have a significant relationship between their scores and neuropsychological measures (Zarantonello, 1988). Using a sample of individuals with various levels of neuropsychological impairment, Zarantonello (1988) examined the relationship between the WAIS and WAIS-R and neuropsychological measures from the Halstead-Reitan Battery. Participants obtained lower IQ scores on the WAIS and WAIS-R as the level of neuropsychological impairment increased. No significant differences were shown between the WAIS and the WAIS-R at various levels of neuropsychological impairment because a relationship exists between the WAIS scores and other neuropsychological measures (Zarantonello, 1988).

Johnstone et al. (1997) examined the construct validity of the Category Test by investigating its relationship between several widely used assessment measures, including the WAIS-R as a measure of intelligence, in a sample with various cognitive impairments. The investigators used a factor analysis to see which assessment measures loaded on each factor of the Category Test. The results showed that Information, Vocabulary, Arithmetic, Comprehension, and Similarities from the WAIS-R loaded on Factor 1 of the Category Test, Verbal Intelligence. Digit Span and Digit Symbol Coding from the WAIS-R loaded on Factor 4 of the Category Test, Processing Speed. The WAIS-R subtests of Picture Completion, Picture Arrangement, Object Assembly, and Block Design did not load on any factors of the Category Test.

Berger (1998) administered the Wechsler Adult Intelligence Scale-Revised (WAIS-R), the Wechsler Memory Scale-Revised, and the Halstead Reitan Neuropsychological Test Battery to 112 patients to examine the relationship between the WAIS-R and neuropsychological and memory measures. The results showed that the WAIS-R scores on the Verbal Comprehension, Perceptual Organizational, and the Freedom from Distractibility factors of the WAIS-R all correlated with the neuropsychological and memory measures. The Verbal Comprehension factor correlated with the Category Test. The Perceptual Organizational factor correlated with the Category Test, TMT Part A (Trails A), TMT Part B (Trails B), Finger Tapping Test (FTT), and Tactual Performance Test. The Freedom From Distractibility factor correlated with the Category Test, Trails A, and Trails B. The author concluded that the WAIS-R factors provide a model that can be utilized in further understanding the cognitive processes that underlie neuropsychological test performance, and when used in conjunction with neuropsychological tests, can assist in the clarification of deficits seen in neuropsychological test performance. Berger (1998) went on to state that the Verbal Comprehension factor was related not only to verbal abilities but also executive function. The Perceptual Organizational factor was shown to be highly correlated with each neuropsychological measure used in the study. The Category Test was correlated with each factor of the WAIS-R. Berger (1998) concluded that this was most likely the result of the fact that many neuropsychological measures, like the Category Test, assess a variety of functions.

Sherman et al. (1995) examined the relationship between the WAIS-R and neuropsychological measures that were said to assess the same abilities. The results of the study indicate that the Verbal Comprehension factor (i.e., Vocabulary, Information, Comprehension, and Similarities) was related to verbal ability, verbal memory, and executive functioning. The Perceptual Organization factor (i.e., Block Design, Object Assembly, Picture Completion, and Object Assembly) primarily assessed visual-spatial perception and visual constructional ability but was related to visual-spatial memory, visual attention, and executive functioning. The Freedom From Distractibility factor (i.e., Arithmetic and Digit Span) was associated with measures of attention but not measures of memory. The authors indicated that the correlations between the WAIS-R and neuropsychological measures were moderate in size.

Golden et al. (1998) examined the Category Test and the WCST and their relationship with the WAIS-R in a sample of brain injured clients. The researchers used the subtest scores of the WAIS-R and examined each subtest's ability to predict scores on the Category Test and the WCST. The results revealed that the Category Test was related to the WAIS-R subtests of Block Design and Picture Arrangement. Golden et al. (1998) hypothesized that the explanation may be that variations seen in performance on the Category Test were the result of spatial and sequential reasoning as would be used in Block Design and Picture Arrangement. The WCST was correlated with Similarities and Object Assembly, and it was suggested that verbal categorization, important for Similarities, and the ability to imagine whole objects, important for Object Assembly, were skills required for performance on the WCST. The overall results from the study indicated that the WCST could be more indicative of verbal abstract skills than the Category Test that appears to rely more on spatial skills (Golden et al., 1998).

Research with the WAIS-III has shown the test to be correlated with neuropsychological measures. Sanchez-Cubillo et al. (2009) examined the TMT and the cognitive abilities it measures. The results showed that Digit Symbol Coding from the WAIS-III accounted for the most variance in performance on Trails A, indicating that the measure was mostly impacted by the speed of visual searching as used in Digit Symbol Coding. Digit Span Backward accounted for a large portion of the variance seen in performance on Trails B, showing that skills used on this task, like the ability to manipulate information in working memory, contributed the most to performance on Trails B (Sanchez-Cubillo et al., 2009).

Dugbartey, Sanchez, Rosenbaum, Mahurin, Davis, and Townes (1999) evaluated the relationship between the Matrix Reasoning subtest on the WAIS-III and the Category Test. Specifically, whether Matrix Reasoning was associated with performance on measures of verbal abstract and verbally mediated thinking. Matrix Reasoning was administered to a group of English and non-English-speaking adults. The results showed a modest relationship between the Category Test and Matrix Reasoning in complex spatial abstract reasoning and using conceptual rules in reasoning. A significant relationship was observed between Matrix Reasoning and verbal fluency and higher order verbal conceptualization in both English-speaking and non-English-speaking adults. The authors concluded that these results suggested a strong verbal mediation component of Matrix Reasoning but stated that executive functions may explain the relationship observed between Matrix Reasoning and higher order conceptual skills as assessed by the Category Test.

Titus et al. (2002) showed a modest relationship between scores on the Category Test and PIQ on the WAIS-III. The subtests that most significantly predicted scores on the Category Test were Block Design, Object Assembly, and Matrix Reasoning. Verbal measures from the WAIS-III (i.e., Letter-Number Sequence, Arithmetic, Information, and Digit Span) correlated with the Category Test but not as strongly as the Performance measures. These findings led the authors to conclude that, while the Category Test was not solely a measure of nonverbal intelligence, the test does require a higher level of nonverbal over verbal intelligence.

Devaraju-Backhaus et al. (2001) investigated the relationship between the Luria-Nebraska Neuropsychological Battery-Third Edition (LNNB-III) and the WAIS-III. The results showed a significant relationship between the WAIS-III subtest of Letter-Number Sequencing and Complex Auditory skills, Visual-Spatial skills, Arithmetic, and Non-verbal Auditory function subtests of the LNNB-III. Matrix Reasoning of the WAIS-III was shown to highly correlate with Visual-Spatial, Arithmetic, Figural Memory, and Non-verbal Auditory function subtests of the LNNB-III. The research was further evidence that the WAIS-III shares a relationship with measures of neuropsychological functioning and may assess similar abilities.

Other research has been conducted to examine specific subtests of previous versions of the WAIS and neuropsychological measures. Davis and Pierson (2012) examined the relationship between the WAIS-III Digit Symbol Coding subtest and executive functioning among a sample of 63 college students. Executive functions were assessed with the Delis-Kaplan Executive Functions System (D-KEFS) TMT. The authors found that the Digit Symbol Coding subtest was correlated with the Letter-Number Sequencing component of the D-KEFS TMT.

The previous research supports the notion that the skills assessed by the former versions of the WAIS have a direct relationship with those assessed by neuropsychological measures. To date, little research has been done to examine the relationship between the WAIS-IV and measures used in neuropsychological assessments or, taking into account the improvements to the test, to examine the differences between the WAIS-III and WAIS-IV on neuropsychological measures. Because the WAIS-IV is said to be more closely aligned with current theories concerning cognitive abilities, the WAIS-IV should be more correlated with neuropsychological measures than the WAIS-III.

Purpose

The purpose of the study was to examine the neuropsychological utility of the WAIS-IV compared to the WAIS-III. The study aimed to determine if the WAIS-IV was more useful at predicting performance on neuropsychological measures than the WAIS-III.

Hypothesis one. Based on the revisions made to the WAIS-IV to coincide with theoretical changes and to be a better assessment of frontal lobe skills, it was expected that the subtests of the WAIS-IV would better predict performance on the neuropsychological measure of the Category Test than the WAIS-III.

Each revision of the WAIS has provided an assessment tool that bares a relationship with neuropsychological assessments and a measure that more closely resembles current research and assessment theories (Benson et al., 2010). The results of previous research examining the WAIS-R have shown that the subtests of the WAIS-R were correlated with scores on the Category Test (Berger, 1998; Golden et al., 1998). Modest relationships have been shown between the Category Test and Matrix Reasoning and other subtests of the WAIS-III (Dugbartey et al., 1999; Titus et al., 2002). Specifically, Dugbartey et al. (1999) concluded that the Category Test measured complex spatial abstract reasoning and was more closely related to Matrix Reasoning subtest of the WAIS-III. There is little literature examining the WAIS-IV and performance on the Category subtest. With the addition of Visual Puzzles, that is proposed to be a measure of frontal lobe functioning, the WAIS-IV was expected to be better able to account for the variance seen in performance for Category errors over the WAIS-III.

Hypothesis two. Due to the revisions made to the WAIS-IV to coincide with theoretical changes and to be a purer measure of processing speed, it was expected that the subtests of the WAIS-IV would better predict dominant hand performance on FTT than the WAIS-III.

Often, the dominant hand FTT performance is accepted as a pure measure of psychomotor speed, a simple response time task (Kennedy, Clement, & Curtiss, 2003).

Some classify motor speed as one of three domains of processing speed (Suchy, Eastvold, Strassberg, & Franchow, 2014). With the WAIS-IV being designed to be a stronger measure of processing speed, it is reasonable to hypothesize that it would be able to better predict dominant hand performance than the WAIS-III.

Additionally, the results of previous research examining the WAIS-R have shown that the subtests of the WAIS-R were correlated with scores on the FTT (Berger, 1998). Specifically, Berger (1998) found that the FTT was correlated with performance on the non-verbal subtests of the WAIS-R. These results have not been repeated using newer versions of the WAIS. Thus, since each revision of the WAIS has provided an assessment tool that has a relationship with neuropsychological assessments and a measure that more closely resembles current research and assessment theories (Benson et al., 2010), it is reasonable to expect that the WAIS-IV would better predict or be more correlated with performance on the FTT than the WAIS-III.

Hypothesis three. Based on the revisions made to the WAIS-IV to coincide with theoretical changes and to be a purer measure of processing speed, it was expected that the subtests of the WAIS-IV would better predict non-dominant hand performance on FTT than the WAIS-III.

The results of previous research examining the WAIS-R have shown that the subtests of the WAIS-R were correlated with scores on the FTT (Berger, 1998). These results have not been repeated using newer versions of the WAIS. Thus, since each revision of the WAIS has provided an assessment tool that bares a relationship with neuropsychological assessments and a measure that more closely resembles current research and assessment theories (Benson et al., 2010), it is reasonable to expect that the

WAIS-IV would better predict or be more correlated with performance on the FTT than the WAIS-III.

Hypothesis four. Based on the revisions made to the WAIS-IV to coincide with theoretical changes and to more closely assess processing speed and working memory, it was expected that the subtests of the WAIS-IV would better predict performance on Trails A than the WAIS-III.

Previous research has shown that the WAIS-R and WAIS-III were closely related to neuropsychological measures. Results have shown that particular subtests from the WAIS-III can account for the variance in performance on neuropsychological measures like Trails A and Trails B (Sanchez-Cubillo et al., 2009). Specifically, the Digit Symbol Coding and Digit Span subtests of the WAIS-III were used to assess speed of perceptual processing and visual scanning and working memory and mental control, respectively. Results showed that 45% of the variance in performance on Trails A was explained by visual searching, as measured by WAIS-III Digit Symbol Coding. An initial finding that WAIS-III Digit Span Backward accounted for 24% of the variance in Trails A disappeared once visual scanning and perceptual speed were controlled for. Indicating that WAIS-III Digit Symbol Coding likely holds a significant relationship with Trails A (Sanchez-Cubillo et al., 2009). Based on the previous research and the changes to the WAIS-IV to make the measure a better measure of processing speed and working memory, it was hypothesized that the WAIS-IV would be a better predictor of performance on Trails A than the WAIS-III.

Hypothesis five. Based on the revisions made to the WAIS-IV to coincide with theoretical changes and to be a better assessment of working memory, processing speed, and frontal skills, it was expected that the subtests of the WAIS-IV would better predict performance on Trails B than the WAIS-III.

The results of previous research has revealed that the greatest portion of the variance in performance on the Trails B was accounted for by Digits Backward of the Digit Span subtest from the WAIS-III, even when visual searching (i.e., Digit Symbol Coding) was controlled for, leading to the conclusion of the authors that working memory (i.e., the ability to mentally manipulate information) may play a role in the implementation of executive control involved in task switching (Sanchez-Cubillo et al., 2009). Thus, this relationship between measures of working memory, visual scanning, and processing speed measures seen between the Trails B and the WAIS-III leads to the reasonable assumption that the WAIS-IV measures would be better predictors of performance on the Trails B, due to the test's revision being more consistent with current assessment theories and neuropsychological measures.

Hypothesis six. Based on the revisions made to the WAIS-IV to coincide with theoretical changes and to be a better measure of fluid reasoning and frontal skills, it was expected that the subtests of the WAIS-IV would better predict performance on the neuropsychological measure WCST than the WAIS-III.

Previous research examining the WAIS-R has shown that the subtests of the WAIS-R were correlated with scores on the WCST (Golden et al., 1998). Specifically, the WCST was correlated with Similarities and Object Assembly, and it was suggested that verbal categorization, important for Similarities, and the ability to imagine whole objects, important for Object Assembly, were skills required for performance on the WCST. Since previous research has shown a relationship between WCST and WAIS subtests and because the WAIS-IV aimed to be a better measure of fluid reasoning and executive abilities, it was expected that the WAIS-IV would be better able to predict performance on the WCST over the WAIS-III.

CHAPTER III

Method

Participants

The current study involved the analysis of archival data from two databases. Participants consisted of adults referred for neuropsychological evaluation at the Neuropsychology Assessment Center at Nova Southeastern University and adults who volunteered to participate in research and receive a full neuropsychological evaluation. Participants included 91 adults of ages 18 to 78 (M = 33.38; SD = 15.03) with 7 to 20 years of education (M = 14.09; SD = 2.30). Females comprised 55% of the sample. The ethnic and racial make up of the sample consisted of 59% Caucasian, 9% African American, 24% Latino-Hispanic, and 8% Other. Diagnostically, the sample was made of 63% with no DSM-IV diagnosis, 11% with a Reading Disorder diagnosis, 8% with a Math Disorder diagnosis, 7% with a Cognitive Disorder NOS diagnosis, 3% with an Anxiety Disorder diagnosis, 3% with a Major Depressive Disorder diagnosis, 2% with an Adjustment Disorder diagnosis, 2% with a Dysthymia diagnosis, and 1% ADHD Combined Type diagnosis.

Procedures

Data collection. For the purposes of this research, all data were collected from psychological evaluations of adults referred to the Neuropsychological Assessment Center at Nova Southeastern University and from volunteer research participants. Doctoral level clinical psychology practicum students, under the supervision of a licensed clinical psychologists at Nova Southeastern University, administered all of the measures. All students completed Nova Southeastern University Citi training. Multiple measures were administered as part of the complete battery, but only the TMT, the Category Test, FTT, WCST, WAIS-III, and WAIS-IV were included in the analyses.

Institutional Review Board Requirement

Before any data were analyzed, approval was obtained from the Institutional Review Board (IRB) at Nova Southeastern University to conduct archival research. As mandated by the IRB, all data were de-identified in order to maintain confidentiality.

Measures

The measures selected involved standardized scores. The measures yielded T-Scores with a mean of 50 and standard deviation of 10 and Standard Scores with a mean of 100 and a standard deviation of 15. Because the standard scores were age and education corrected, the raw scores were used in the current study. The measures consisted of instruments described as assessments of verbal abilities, perceptual skills, motor speed, and executive functions and are detailed below.

The Trail Making Test. The Trails Making Test (TMT) is made up of two parts, Trails A and Trails B. The individual is asked to draw lines connecting numbers in sequential order as quickly and accurately as possible in the Trails A. The Trails B involves the client completing the same task but alternating between numbers and letters in sequential order. The TMT is often used as a measure of visual conceptual abilities, cognitive flexibility, set shifting, sequencing ability, visual-motor tracking, and visual-spatial functioning. The TMT has been shown to be highly sensitive to brain injury and has a large attentional component. Trails B is often considered one of the best indicators of cerebral dysfunction (Golden, Espe-Pfeifer, & Wachsler-Felder, 2000).

Finger Tapping Test (FTT). The Finger Tapping Test (FTT) is used to assess an individual's motor dexterity and manual motor speed (Sanchez-Cubillo et al., 2009). The individual is asked to place his or her hand flat on a board and place the index finger of the dominant hand on a lever that moves up and down and is attached to a device with a counter. The person is then asked to push or tap the lever making it move up and down as quickly as possible for 10 seconds. The counter on the device records the number of taps the individual achieves. The administration for each hand continues until the client achieves five consecutive trials within a five tap range or ten trials are completed. The process is then repeated with the non-dominant hand. The averages of the five consecutive trials within a five tap range or all ten trials are calculated for each hand. The FTT is often used to assess for brain dysfunction and to identify the lateralization of specific lesions (Golden, Espe-Pfeifer, & Wachsler-Felder, 2000).

Wisconsin Card Sorting Test (WCST). The Wisconsin Card Sorting Test (WCST) is used to evaluate an individual's ability to learn concepts. The test is a computerized task with four stimulus cards and one response deck. The stimulus cards are made up of a card with one red triangle, a card with two green stars, a card with three yellow crosses, and a card with four blue circles. The response deck consists of 128 cards that have varying geometric shapes (i.e., circle, square, triangle, or cross), colors (i.e., red, yellow, green, or blue), and numbers of shapes (i.e., one, two, three, or four). The cards from the deck are comprised of all possible combinations of color, form, and number. The individual is asked to match each card from the deck to one of the four stimulus cards and is not instructed how to match the cards from the deck. One opportunity is given to match each card in the deck, and the computer provides audio and visual feedback to the individual by displaying and stating the words "correct" or "incorrect" after each response. The individual must use this feedback to modify responses until reaching the desired response. After reaching 10 consecutive correct response matches (e.g., color, form, or number), the criterion for matching changes. The test begins with color, changes to form, then number, and then goes back through color, form, and number categories. Scores consists of number of correct responses, perseverative errors (i.e., responses that would have been correct on a previous category), nonperseverative errors, and the total number of categories completed (Golden, Espe-Pfeifer, & Wachsler-Felder, 2000).

Wechsler Adult Intelligence Scale-III (WAIS-III). The Wechsler Adult Intelligence Scale-III (WAIS-III; The Psychological Corporation, 1997) is a series of tests used to assess general intelligence in an adult population of ages ranging from 16 to 89 years. The test consists of measures of general information knowledge, word definitions, problem solving, and visual-spatial processing.

The WAIS-III is divided into Verbal and Performance sections. The Verbal section has 7 subtests (i.e., Vocabulary, Similarities, Arithmetic, Digit Span, Information, Comprehension, and Letter Number Sequence) that contribute to the Verbal IQ score. The Vocabulary subtest is a measure of general word knowledge, where an individual is asked to define single words. Similarities involves asking an individuals how two words are alike and is a measure of verbal abstract reasoning. Arithmetic is a measure of working memory and mental control under timed conditions, where an individual is asked to mentally compute simple arithmetic problems under timed conditions. The Digit Span subtest assess immediate attention, asking an individual to recite a series of numbers, initially, in the same order that the numbers were heard. A second part of the subtest asks the individual to recite the numbers in the reverse order in which they were heard. The Information subtest involves an individual being asked general questions about everyday information and assesses general fund of knowledge. Comprehension is a subtest of everyday reasoning and involves answering questions about everyday problems. Letter-Number Sequencing is another subtests assessing working memory and immediate attention. The subtest requires an individual to recite a string of numbers and letters in an order that lists the numbers first in numerical order and the letters last in alphabetical order.

The Performance section consists of 7 additional subtests (i.e., Picture Completion, Digit Symbol Coding, Block Design, Matrix Reasoning, Picture Arrangement, Symbol Search, and Object Assembly) that contribute to the Performance IQ score. The Picture Completion subtest assesses attention to detail and visual discrimination. The subtest requires the individual to find a missing part of a picture under timed constraints. Digit Symbol Coding is a measure of speeded transcription of symbols using a key, assessing processing speed and psychomotor speed. Block Design is a measure of three-dimensional visuoconstructional abilities under timed conditions. Matrix Reasoning is a measure of visuospatial problem solving. Symbol Search is a measure that requires visual scanning and processing speed. The Verbal and Performance subtests combine to generate a Full Scale IQ.

Wechsler Adult Intelligence Scale-IV (WAIS-IV). Loring and Bauer (2010) discuss the changes to the WAIS-IV and state that revisions to the test allow improvements in test content that coincide with current research and theoretical models of cognitive function. Changes from the WAIS-III to the WAIS-IV include scale indices, subtest content, and administration. The index scores include the Verbal Comprehension Index (VCI), Perceptual Reasoning Index (PRI), Processing Speed Index (PSI), and Working Memory Index (WMI). The core subtests included on the WAIS-IV are the Vocabulary, Information, Similarities, Arithmetic, Digit Span, Block Design, Matrix Reasoning, Visual Puzzles, Coding, and Symbol Search. The test includes five supplemental tests including: Comprehension, Picture Completion, Figure Weights, Letter-Number Sequencing, and Cancellation. For the purposes of this study, only the core subtests were used. The core subtests are largely the same as described previously in the WAIS-III section. Subtest changes from the previous version include shortened discontinue criteria and fewer motor demands as well as fewer timed bonuses, shorter discontinuation rules, and clearer administration instructions and teaching examples. Additionally, Digit Span includes a third sequencing component that requires the individual to recite a series of numbers heard in sequential order from least to greatest. Visual Puzzles is the only new subtest in the core group of subtests and involves looking at a picture and identifying three pieces from six options that make the pictured puzzle. The individual is asked to complete the task within a given time frame. The test was standardized on ages ranging from 16 to 90 years.

Category Test. The Category Test consists of seven subtests that involve a series of images that suggest a number from 1 to 4. The first subtest has items that are Roman numerals ranging from 1 to 4 (I, II, III, IV). The second subtest requires the individual to count the number of objects on the computer screen. For the more complex subtests (3 through 6), the number is suggested by the spatial location, orientation of an odd or specific item, or through proportional reasoning. The final subtest is made up of items from other subtest that the individual has seen before. The individual must guess the appropriate strategy to use in each subtest and is allowed one guess per item. A bell signals a correct response and a buzzer signals an incorrect response for each item. This feedback allows the individual to alter responses until finding the appropriate strategy to respond correctly. The individual's score is determined by the number of errors the individual makes on the seven subtests (Golden, Espe-Pfeifer, & Wachsler-Felder, 2000).

Analyses

Preliminary Analyses. Demographic variables of age and education were collected for each participant. Participant diagnoses were gathered and the distribution of diagnoses for the sample was recorded. The Statistical Package for the Social Sciences (SPSS) was employed for analysis of data in the study.

Due to the sensitivity of multiple regression analyses to data outliers, the statistical assumptions of multiple regressions were assessed before the data were analyzed. Predictor and dependent variables were examined for outliers. Specifically, analyses were run to examine the student deleted residuals, the leverage, and the multicollinearity for each model.

Regression Analyses. To evaluate hypotheses one through six, Pearson correlations and hierarchical multiple regression analyses were used to see if raw subtest scores on the WAIS-III and WAIS-IV were able to predict scores on neuropsychological measures (i.e., Trails A and B, WCST, Category, and FTT) in a sample of adults. While Standard Scores for the WAIS-III and IV were age corrected, T-scores for the neuropsychological measures were age, education, gender, and race corrected. Additionally, the Standard and T-scores were based on two different scales, making the scores difficult to compare. Thus, based on these factors, raw scores were used in the multiple regression analyses in order to ensure that the scores being compared were the same in nature. Age and education were entered as predictor variables in the first block of the hierarchical regression, in order to assess their contribution to the models. The raw subtest scores were used as the predictor variables in the second block in the hierarchical regression models. Multiple regression analyses were conducted for each of the six neuropsychological measures. The differences in the regression coefficients, R^2, for the WAIS-III and WAIS-IV raw subtest scores were compared using confidence intervals as proposed by Alf and Graf (1999) to see if the subtests of the WAIS-IV were significantly better predictors of, or accounted for more of the variance in, each neuropsychological measure than the subtests of the WAIS-III.

CHAPTER IV

Results

Preliminary Results

Preliminary results included regression diagnostics, run in order to ensure the regression models' validity. Multiple regression analyses were run to examine the student deleted residuals, the leverage, and the multicollinearity for each model. To assess for outliers scores for centered leverage value and studentized deleted residuals were examined. Leverage is a value used to assess how extreme an observation is in relation to the independent variables, and an accepted leverage value cutoff is considered $2p/n$, where p is the number of predictors including the intercept in the model and n is the sample size (Quinn & Keough, 2002). For the regression models containing the WAIS-III this would be .34 and .22 for the models containing the WAIS-IV. The leverage values were calculated by conducting preliminary regression models in SPSS.

Studentized deleted residuals examine whether an observation is unusual compared to the rest of the sample so much so that it would change the model if that observation were removed. Higher values indicated that the observations were outliers from the other observations (Quinn & Keough, 2002). The general rule of thumb is that a studentized deleted residual of 3 or higher is considered extreme. The studentized deleted residuals were calculated by running preliminary regression models using SPSS.

For the current study, centered leverage, studentized deleted residuals, and DFBETAS were examined to evaluate for outliers and influential observations in the dataset. Those with both high centered leverage and high student deleted residuals (i.e., 3 and above) were considered extreme observations. These preliminary diagnostics showed three participants with extreme scores (i.e., high studentized deleted residual, high centered leverage values, and high DFBETAS) that were removed from the dataset, as not to distort the regression models or coefficient estimates. Thus, the remaining results were run with a sample size of 91 individuals.

SPSS was used to conduct multiple regression analyses with the outlier reduced dataset to examine multicollinearity (i.e., multiple variables in the regression model have exact linear relationships). When present, multicollinearity impacts the coefficients of the regression model and the standard error of each coefficient becomes inflated. Accepted or rule of thumb cutoff values for multicollinearity is a variance inflation factor (VIF) of greater than 5. For each regression model, no variables exhibited a VIF of 5 or above, which would rule out multicollinearity issues.

Table 1 illustrates the descriptive statistics for the neuropsychological measures in the sample. All variables had an approximately normal distribution. A .01 significance value was employed for all analyses in order to ensure a conservative approach to testing the hypotheses and lowering the chances of a type I error. Table 2 shows the correlations between all the WAIS-III and WAIS-IV subtests in the sample. Most subtests of the WAIS-III and WAIS-IV were significantly correlated with one another, with the exception of WAIS-III Vocabulary and WAIS-IV Symbol Search, WAIS-III Digit Symbol Coding and WAIS-IV Information, and WAIS- III Digit Span with WAIS-IV Information, WAIS-III Information with WAIS-IV Visual Puzzles, WAIS-III Vocabulary and WAIS-IV Coding, WAIS-III Comprehension and WAIS-IV Symbol Search, and WAIS-III Comprehension and WAIS-IV Coding.

The results of the correlations between the neuropsychological measures and the

Table 1

Descriptive Statistics for Neuropsychological Measures in the Sample

Measure	N	*M*	*SD*	Skewness	Kurtosis
Trails A	91	27.76	9.90	.97	1.34
Trails B	91	72.41	42.20	3.00	13.00
WCST Perseverative Errors	91	8.51	4.23	1.70	4.22
Category Number of Errors	91	46.58	29.14	.78	-.32
Finger Tapping Test – Dominant	91	47.49	7.23	-.36	.42
Finger Tapping Test – Non-dominant	91	43.96	7.03	-.06	.89
WAIS-III Picture Completion	91	20.13	3.16	-1.46	2.59
WAIS-III Vocabulary	91	46.91	11.72	-.393	-.880
WAIS-III Digit Symbol Coding	91	74.62	18.80	-.445	.211
WAIS-III Similarities	91	24.46	4.85	-.50	-.20
WAIS-III Block Design	91	41.88	14.41	-.17	-.72
WAIS-III Arithmetic	91	12.77	3.88	.05	-.92
WAIS-III Matrix Reasoning	91	18.25	4.71	-.95	.34
WAIS-III Digit Span	91	17.55	4.90	.28	-.19
WAIS-III Information	91	17.67	4.79	-.53	-.51
WAIS-III Picture Arrangement	91	14.11	4.82	-.61	-.13
WAIS-III Comprehension	91	22.26	5.78	-.48	-.05
WAIS-III Symbol Search	91	34.31	9.68	-.09	-.33
WAIS-III Letter Number Sequencing	91	11.27	2.99	.23	-.28
WAIS-IV Block Design	91	41.23	13.17	-.15	-.95
WAIS-IV Similarities	91	26.03	5.56	-.61	-.09
WAIS-IV Digit Span	91	28.19	6.02	-.19	.17
WAIS-IV Matrix Reasoning	91	19.03	4.23	-.70	.21
WAIS-IV Vocabulary	91	38.89	10.00	-.39	-.74
WAIS-IV Arithmetic	91	13.07	3.65	.12	-.68
WAIS-IV Symbol Search	91	32.64	9.28	-.18	-.64
WAIS-IV Visual Puzzles	91	15.25	4,89	-.08	-1.05
WAIS-IV Information	91	15.03	4.78	-.29	-.53
WAIS-IV Coding	91	72.09	17.17	-.26	-.30

Note. *M* = mean; *SD* = Standard Deviation

WAIS-III are found in Table 3. Of the neuropsychological measures, the WCST and Category exhibited significant negative correlations with all of the WAIS-III subtests.

Table 2

Pearson Correlations between WAIS-III and WAIS-IV

WAIS-III	WAIS-IV									
	BD	SI	DS	MR	VC	AR	IN	SS	VP	CD
PC	.60*	.48*	.37*	.55*	.34*	.46*	.38*	.44*	.59*	.49*
VC	.42*	.68*	.44*	.39*	.89*	.56*	.68*	.20	.29*	.20
CD	.54*	.34*	.47*	.49*	.28*	.48*	.22	.60*	.44*	.78*
SM	.55*	.75*	.38*	.49*	.73*	.61*	.63*	.30*	.40*	.32*
BD	.89*	.50*	.50*	.65*	.41*	.65*	.30*	.55*	.80*	.51*
AR	.62*	.61*	.52*	.45*	.58*	.85*	.56*	.47*	.48*	.46*
MR	.74*	.44*	.54*	.69*	.37*	.58*	.42*	.61*	.63*	.57*
DS	.47*	.31*	.74*	.47*	.35*	.45*	.14	.53*	.48*	.46*
IN	.40*	.57*	.35*	.47*	.76*	.59*	.86*	.30*	.21	.32*
PA	.56*	.45*	.35*	.59*	.52*	.44*	.48*	.36*	.43*	.42*
CP	.43*	.66*	.38*	.38*	.73*	.57*	.67*	.23	.28*	.23
SS	.70*	.46*	.52*	.59*	.32*	.56*	.28*	.77*	.67*	.76*
LS	.59*	.48*	.70*	.51*	.58*	.54*	.38*	.53*	.58*	.45*

Note. * = $p \leq .01$; PC = Picture Completion; VC = Vocabulary; CD = Digit Symbol Coding; SM = Similarities; BD = Block Design; AR = Arithmetic; MR = Matrix Reasoning; DS = Digit Span; IN = Information; PA = Picture Arrangement; CP = Comprehension; SS = Symbol Search; LS = Letter Number Sequencing; VP = Visual Puzzles

Thus, as the raw scores on the WAIS-III subtest decreased the errors on the WCST and

Category increased. Trails A was correlated significantly with all of the subtests of the

Table 3

Pearson Correlations between Neuropsychological Measures and WAIS-III

WAIS-III	Neuropsychological Measures					
	Trails A	Trails B	FTT Dominant	FTT Non-Dominant	WCST	Category
PC	-.45*	-.49*	.28*	.24	-.37*	-.59*
VC	-.28*	-.25	.07	.01	-.28*	-.39*
CD	-.56*	-.48*	.31*	.28*	-.50*	-.55*
SM	-.38*	-.40*	.22	.16	-.38*	-.53*
BD	-.47*	-.44*	.34*	.23	-.49*	-.71*
AR	-.49*	-.52*	.25	.18	-.34*	-.63*
MR	-.47*	-.53*	.25	.18	-.54*	-.60*
DS	-.51*	-.50*	.25	.20	-.34*	-.49*
IN	-.30*	-.31*	.05	.05	-.38*	-.38*
PA	-.37*	-.47*	.26	.19	-.53*	-.55*
CP	-.25	-.26	.06	-.01	-.28*	-.43*
SS	-.62*	-.54*	.35*	.32*	-.48*	-.67*
LS	-.54*	-.50*	.34*	.23	-.40*	-.53*

Note. * = $p \leq .01$; PC = Picture Completion; VC = Vocabulary; CD = Digit Symbol Coding; SM = Similarities; BD = Block Design; AR = Arithmetic; MR = Matrix Reasoning; DS = Digit Span; IN = Information; PA = Picture Arrangement; CP = Comprehension; SS = Symbol Search; LS = Letter Number Sequencing

WAIS-III with the exception of Comprehension. Similarly, Trails B was significant with all WAIS-III subtests except Vocabulary and Comprehension. FTT Dominant was only correlated with the WAIS-III subtests of Picture Completion, Digit Symbol Coding, Block Design, Symbol Search, and Letter Number Sequencing. FTT Non-Dominant was only correlated with Digit Symbol Coding and Symbol Search of the WAIS-III.

Table 4 shows the correlations between the WAIS-IV subtests and the neuropsychological measures. Trails A was significantly correlated with all subtests with the exception of Vocabulary and Information. Trails B was significantly correlated with all of the WAIS-IV subtests. FTT Dominant was only correlated with Block Design, Digit Span, Visual Puzzles, and Coding. FTT Non-Dominant was only correlated with Visual Puzzles and Coding. WCST was significantly correlated with all subtests except Information. Category was significantly correlated with all subtests.

Hypothesis 1

The first hypothesis stated that, based on the revisions made to the WAIS-IV to coincide with theoretical changes and to more closely resemble neuropsychological assessment measures, it was expected that the subtests of the WAIS-IV would better predict the Category Test than would the WAIS-III. The first block of the hierarchical regression contained age and education predicting Category Test scores and was significant, $R^2 = .18$, $F(2, 88) = 9.62$, $p < .001$. The WAIS-III subtests were added to a second variable block of the hierarchical regression and was significant, $\Delta R^2 = .52$, F Change(13, 75) = 9.83, $p < .001$, showing that they contribute above and beyond age and education, $R^2 = .70$, $F(15, 75) = 11.47$, $p < .001$. In a separate hierarchical regression age and education were entered as the first block of the hierarchical regression. The second block with the WAIS- IV subtests was significant, $\Delta R^2 = .46$, F Change(10, 78) = 9.97, $p < .001$, indicating that the subtests account for a significant amount of variance over and above age and education alone, $R^2 = .64$, $F(12, 78) = 11.55$, $p < .001$. Tables 5 and 6 show the individual predictive values for each predictor entered in both hierarchical regression models as well as the confidence intervals.

Table 4

Pearson Correlations between Neuropsychological Measures and WAIS-IV

WAIS-IV	Neuropsychological Measures					
	Trails A	Trails B	FTT Dominant	FTT Non-Dominant	WCST	Category
Block Design	-.46*	-.46*	.32*	.22	-.42*	-.63*
Similarities	-.39*	-.42*	.16	.11	-.34*	-.52*
Digit Span	-.39*	-.45*	.27*	.28	-.31*	-.51*
Matrix Reasoning	-.44*	-.38*	.22	.15	-.60*	-.61*
Vocabulary	-.24*	-.31*	.07	.07	-.30*	-.39*
Arithmetic	-.52*	-.53*	.26	.20	-.34*	-.58*
Information	-.25*	-.27*	.04	.14	-.26	-.36*
Symbol Search	-.55*	-.52*	.23	.08	-.47*	-.57*
Visual Puzzles	-.49*	-.52*	.43*	.37*	-.37*	-.64*
Coding	-.60*	-.56*	.31*	.34*	-.46*	-.62*

Note. * = $p \leq .01$

To evaluate the differences in the predictive ability of the two versions of the WAIS, the squared multiple correlation coefficients (i.e., R^2) were compared using a method proposed by Alf and Graf (1999). With an R^2 difference of 0.06, the 99% confidence interval produced by the Alf and Graf (1999) model had a lower limit of -0.02

and an upper limit of 0.13, as seen in Table 7. The comparison of the R^2 difference was not significant. Thus, neither model was a significantly better predictor of performance on Category than the other. The hypothesis was not supported.

Hypothesis 2

The second hypothesis hypothesized that the WAIS-IV would be a better predictor of performance on the FTT for the dominant hand over the WAIS-III. The first block of both hierarchical regressions contained age and education predicting dominant hand performance on the FTT which were not significant, $R^2 = .07$, $F(2, 88) = 3.52$, $p = .034$. For the first hierarchical regression, the second block contained the WAIS-III subtests and showed that the predictors did not account for a significant amount of the variance in dominant hand performance on the FTT, $\Delta R^2 = .22$, F Change$(13, 75) = 1.83$, $p = .05$, $R^2 = .30$, $F(15, 75) = 2.11$, $p = .02$. The second hierarchical regression contained the WAIS-IV subtests in the second block and was significant overall, $\Delta R^2 = .21$, F Change$(10, 78) = 2.30$, $p = .02$, which indicated that the subtests contribute over and above age and education, $R^2 = .29$, $F(12, 78) = 2.59$, $p = .006$, for predicting performance on the FTT with the dominant hand. Tables 8 and 9 show the individual predictive values and confidence intervals for each predictor entered in both hierarchical regression models. With an R^2 difference of 0.01, the 99% confidence interval produced by the Alf and Graf (1999) model was not significant and had a lower limit of -0.04 and an upper limit of 0.06, as shown in Table 7. Hypothesis two was not supported, as the WAIS-IV was not a significantly better predictor of performance on the FTT for the dominant hand.

Hypothesis 3

The third hypothesis examined the predictive ability of the versions of the WAIS

Table 5

Summary of Multiple Regressions for Variables Predicting Category Error Performance

	WAIS-III				WAIS-IV			
Variable	*B*	*SE B*	β	sr^2	*B*	*SE B*	β	sr^2
Age	.72	.19	.37*	.14	.72	.19	.37*	.14
Education	-3.61	1.25	-.29*	.08	-3.61	1.25	-.29*	.08
Age	.51	.17	.26*	.04	.27	.18	.14	.01
Education	-.66	1.06	-.05	.00	.50	1.07	.04	.00
Information	.63	.76	.10	.00	-.26	.64	-.04	.00
Digit Span	-.38	.61	-.06	.00	-.09	.46	-.02	.00
Vocabulary	.06	.33	.02	.00	-.12	.36	-.04	.00
Arithmetic	-2.49	.85	-.33*	.04	-.56	.97	-.07	.00
Comprehension	-.86	.61	-.17	.01	-	-	-	-
Similarities	.02	.79	.00	.00	-1.18	.56	-.23	.02
PC	-1.87	.82	-.20	.02	-	-	-	-
PA	-.74	.69	-.12	.01	-	-	-	-
Block Design	-.44	.23	-.22	.01	.11	.30	.05	.00
MR	.76	.76	.12	.00	-1.05	.66	-.15	.01
Coding	.08	.76	.05	.00	-.50	.18	-.30*	.04
LNS	1.04	1.12	.11	.00	-	-	-	-
Symbol Search	-.69	.34	-.23	.02	.17	.35	.05	.00
Visual Puzzles	-	-	-	-	-1.79	.75	-.30	.03

Note. dash = variable not included on specific version of test. *p < .01. *B* = unstandardized coefficient; *SE B* = Standard error of unstandardized coefficient; β = Standardized coefficient; sr^2 = squared semipartial correlation; PC = Picture Completion; PA = Picture Arrangement; MR = Matrix Reasoning

and the FTT for the non-dominant hand, stating that the WAIS-IV would be a better predictor of performance on the FTT for the non-dominant hand over the WAIS-III.

For performance on the FTT with the non-dominant hand, the first block of both hierarchical regressions contained age and education as predictors of performance on the

Table 6

Confidence Intervals for Unstandardized Regression Coefficients for Category Error

Variable	WAIS-III		WAIS-IV	
	99% Confidence Interval		99% Confidence Interval	
	Lower Limit	Upper Limit	Lower Limit	Upper Limit
Age	.22	1.22	.22	1.22
Education	-6.90	-.33	-6.90	-.33
Age	.08	.95	-.21	.74
Education	-3.47	2.14	-2.31	3.31
Information	-1.37	2.63	-1.94	1.43
Digit Span	-1.99	1.23	-1.32	1.13
Vocabulary	-.82	.94	-1.07	.83
Arithmetic	-4.74	-.25	-3.12	1.99
Comprehension	-2.47	.74	--	--
Similarities	-2.08	2.12	-2.65	.28
Picture Completion	-4.04	.30	--	--
Picture Arrangement	-2.55	1.08	--	--
Block Design	-1.04	.17	-.68	.91
Matrix Reasoning	-1.26	2.78	-2.80	.70
Digit Symbol Coding	-.34	.49	-.99	-.01
LNS	-1.92	3.99	--	--
Symbol Search	-1.60	.22	-.76	1.09
Visual Puzzles	--	--	-3.76	.18

Note. Dashes indicate that variable was not included on specific version of test

task and were not significant, $R^2 = .08$, $F(2, 88) = 4.02$, $p = .02$. For the first hierarchical regression, the second block contained the WAIS-III subtests and did not produce a

Table 7

Comparison of the Squared Multiple Correlation Coefficients

Measure	R^2_1	R^2_2	Confidence Interval Lower Limit	Confidence Interval Upper Limit
Category Test Errors	.70	.64	-.02	.13
FTT Dominant Hand	.30	.29	-.04	.06
FTT Non-Dominant Hand	.23	.28	-.14	.06
Trails A	.50	.47	-.04	.78
Trails B	.52	.49	-.04	.88
WCST Perseverative Error	.43	.42	-.03	.04

significant model, $\Delta R^2 = .15$, F Change$(13, 75) = 1.13$, $p = .35$, $R^2 = .23$, $F(15, 75) = 1.53$, $p = .12$. In contrast, the second hierarchical regression contained the WAIS-IV subtests in the second block and was significant, $\Delta R^2 = .19$, F Change$(10, 78) = 2.09$, $p = .04$, revealing that the subtests contribute over and above age and education alone, $R^2 = .28$, $F(12, 78) = 2.49$, $p = .008$, for predicting performance on the FTT with the non-dominant hand. Tables 10 and 11 show the individual predictive values and confidence intervals for each predictor entered in both hierarchical regression models. With an R^2 difference of 0.04, the 99% confidence interval produced by the Alf and Graf (1999) model is shown in Table 7 and was not significant and had a lower limit of -0.14 and an upper limit of 0.06. The hypothesis was not supported, as the WAIS-IV did not produce

Table 8

Summary of Multiple Regressions for Variables Predicting FTT Dominant Performance

	WAIS-III				WAIS-IV			
Variable	*B*	*SE B*	β	sr^2	*B*	*SE B*	β	sr^2
Age	-.11	.05	-.24	.05	-.11	.05	-.24	.05
Education	-.31	.33	-.10	.01	-.31	.33	-.10	.01
Age	-.02	.06	-.05	.00	-.03	.06	-.07	.00
Education	-.77	.40	-.24	.04	-.82	.37	-.26	.04
Information	-.19	.29	-.13	.01	-.09	.22	-.06	.00
Digit Span	-.15	.23	-.10	.00	.08	.16	.06	.00
Vocabulary	-.08	.13	-.13	.00	.02	.13	.03	.00
Arithmetic	.35	.32	.19	.01	.32	.34	.16	.01
Comprehension	-.30	.23	-.24	.02	-	-	-	-
Similarities	.47	.30	.31	.02	.03	.19	.03	.00
Picture Completion	.09	.31	.04	.00	-	-	-	-
Picture Arrangement	.17	.26	.11	.00	-	-	-	-
Block Design	.00	.09	.01	.00	-.04	.11	-.07	.00
Matrix Reasoning	-.02	.29	-.01	.00	.01	.23	.00	.00
Coding	.03	.06	.09	.00	.12	.06	.28	.03
LNS	.73	.42	.30	.03	-	-	-	-
Symbol Search	.04	.13	.06	.00	-.19	.12	-.06	.02
Visual Puzzles	-	-	-	-	.54	.26	.37	.04

Note. dash = variable not included on specific version of test. *p < .01. *B* = unstandardized coefficient; *SE B* = Standard error of unstandardized coefficient; β = Standardized coefficient; sr^2 = squared semipartial correlation

a significantly better model for predicting performance on the FTT for the non-dominant hand.

Hypothesis 4

The fourth hypothesis stated that performance on the WAIS-IV subtests would be

Table 9

Confidence Intervals for Unstandardized Regression Coefficients for FTT Dominant

Variable	WAIS-III		WAIS-IV	
	99% Confidence Interval		99% Confidence Interval	
	Lower Limit	Upper Limit	Lower Limit	Upper Limit
Age	-.25	.02	-.25	.02
Education	-1.18	.56	-1.18	.56
Age	-.19	.14	-.20	.13
Education	-1.83	.29	-1.81	.16
Information	-.95	.56	-.68	.50
Digit Span	-.76	.46	-.35	.51
Vocabulary	-.41	.25	-.31	.35
Arithmetic	-.50	1.20	-.57	1.22
Comprehension	-.91	.30	--	--
Similarities	-.33	1.26	-.48	.55
Picture Completion	-.72	.91	--	--
Picture Arrangement	-.52	.86	--	--
Block Design	-.23	.23	-.32	.24
Matrix Reasoning	-.78	.75	-.61	.62
Digit Symbol Coding	-.12	.19	-.05	.29
LNS	-.39	1.85	--	--
Symbol Search	-.30	.37	-.51	.14
Visual Puzzles	--	--	-.15	1.23

Note. Dashes indicate that variable was not included on specific version of test

better predictors of performance on Trails A than performance on the WAIS-III subtests. The first block of both hierarchical regressions contained age and education predicting performance on Trails A and were significant, $R^2 = .10$, $F(2, 88) = 4.87$, $p = .010$. The

Table 10

Summary of Multiple Regressions for FTT Non-Dominant Performance

	WAIS-III				WAIS-IV			
Variable	*B*	*SE B*	β	sr^2	*B*	*SE B*	β	sr^2
Age	-.12	.05	-.27	.07	-.12	.05	-.27	.07
Education	-.23	.32	-.08	.01	-.23	.32	-.08	.01
Age	-.06	.06	-.13	.01	-.05	.06	-.11	.01
Education	-.68	.41	-.22	.03	-.69	.36	-.23	.03
Information	.11	.29	.07	.00	.07	.22	.05	.00
Digit Span	-.03	.23	-.02	.00	-.03	.16	-.03	.00
Vocabulary	-.12	.13	-.20	.01	-.07	.12	.10	.00
Arithmetic	.35	.33	.19	.01	.17	.33	.09	.00
Comprehension	-.31	.23	-.25	.02	-	-	-	-
Similarities	.45	.30	.31	.02	.03	.19	.02	.00
Picture Completion	.21	.31	.09	.01	-	-	-	-
Picture Arrangement	.05	.26	.04	.00	-	-	-	-
Block Design	-.06	.09	-.12	.01	-.15	.10	-.29	.02
Matrix Reasoning	-.07	.30	-.05	.00	-.17	.23	-.10	.01
Coding	.03	.06	.08	.00	.16	.06	.39	.06
LNS	.33	.43	.14	.01	-	-	-	-
Symbol Search	.08	.13	.11	.00	-.11	.12	-.15	.01
Visual Puzzles	-	-	-	-	.67	.26	.46	.06

Note. dash = variable not included on specific version of test. *p < .01. *B* = unstandardized coefficient; *SE B* = Standard error of unstandardized coefficient; β = Standardized coefficient; sr^2 = squared semipartial correlation first hierarchical regression contained the WAIS-III subtests in the second block and was significant, $\Delta R^2 = .40$, F Change(13, 75) = 4.52, $p < .001$, which shows that the subtests

Table 11

Confidence Intervals for Unstandardized Regression Coefficients for FTT Non-Dominant

Variable	WAIS-III		WAIS-IV	
	99% Confidence Interval		99% Confidence Interval	
	Lower Limit	Upper Limit	Lower Limit	Upper Limit
Age	-.25	.00	-.25	.00
Education	-1.07	.60	-1.07	.60
Age	-.23	.11	-.21	.11
Education	-1.75	.40	-1.65	.27
Information	-.66	.87	-.50	.65
Digit Span	-.64	.59	-.45	.39
Vocabulary	-.46	.22	-.26	.39
Arithmetic	-.51	1.21	-.70	1.05
Comprehension	-.92	.31	--	--
Similarities	-.35	1.26	-.47	.53
Picture Completion	-.63	1.04	--	--
Picture Arrangement	-.64	.75	--	--
Block Design	-.29	.17	-.43	.12
Matrix Reasoning	-.84	.71	-.77	.43
Digit Symbol Coding	-.13	.19	-.01	.33
LNS	-.81	1.46	--	--
Symbol Search	-.27	.43	-.43	.20
Visual Puzzles	--	--	-.01	1.34

Note. Dashes indicate that variable was not included on specific version of test

contribute over and above age and education, $R^2 = .50$, $F(15, 75) = 4.90$, $p < .001$. For the second hierarchical regression, the WAIS-IV subtests were entered in the second block of the hierarchical regression. A significant proportion of the variance in performance on Trails A was shown to be accounted for by age, education, and the WAIS-IV subtests in the second analysis, $\Delta R^2 = .37$, F Change$(10, 78) = 5.54$, $p < .001$, indicating that the subtests contribute over and above education, $R^2 = .47$, $F(12, 78) = 5.85$, $p < .001$. Tables 12 and 13 list the individual predictive values for each predictor entered in both hierarchical regression models as well as the confidence intervals. The Alf and Graf (1999) confidence interval comparison of the regression coefficients showed, with an R^2 difference of .02 and a 99% confidence interval ranging from -.035 to 0.78 (Table 7), that there was no significant difference. Since the WAIS-IV was not shown to be a significantly better predictor of performance on Trails A, the hypothesis was not supported.

Hypothesis 5

For performance on Trails B, hypothesis five hypothesized that the WAIS-IV would be a significantly better predictor of performance on the task over the WAIS-III. For both hierarchical regressions, the first block of the hierarchical regression contained age and education and was significant, $R^2 = .14$, $F(2, 88) = 6.86$, $p = .002$. In the first hierarchical regression, the WAIS-III subtests were entered in the second block of the hierarchical regression and were shown to significantly account for the variance in performance on Trails B, $\Delta R^2 = .38$, F Change$(13, 75) = 4.59$, $p < .001$, over and above age and education alone, $R^2 = .52$, $F(15, 75) = 5.38$, $p < .001$. The second hierarchical regression model contained the WAIS-IV subtests in the second block of the hierarchical

Table 12

Summary of Multiple Regressions for Variables Predicting Trails A Performance

	WAIS-III				WAIS-IV			
Variable	*B*	*SE B*	β	sr^2	*B*	*SE B*	β	sr^2
Age	.16	.07	.24	.05	.16	.07	.24	.05
Education	-1.11	.44	-.26	.06	-1.11	.44	-.26	.06
Age	-.01	.07	-.02	.00	-.01	.07	-.02	.00
Education	-.15	.47	-.03	.00	-.04	.44	-.01	.00
Information	.00	.33	.00	.00	.01	.26	.00	.00
Digit Span	-.21	.27	-.10	.00	-.00	.19	-.00	.00
Vocabulary	.11	.15	.13	.00	.07	.15	.07	.00
Arithmetic	-.25	.38	-.10	.00	-.61	.40	-.23	.02
Comprehension	.21	.27	.12	.00	-	-	-	-
Similarities	-.43	.35	-.21	.01	-.21	.23	-.12	.01
PC	-.45	.36	-.15	.01	-	-	-	-
PA	.21	.30	.10	.00	-	-	-	-
Block Design	.08	.10	.12	.00	.16	.12	.21	.01
MR	-.14	.33	-.07	.00	-.09	.27	-.04	.00
Coding	-.10	.07	-.19	.01	-.22	.08	-.37*	.05
LNS	-.80	.49	-.24	.02	-	-	-	-
Symbol Search	-.23	.15	-.23	.02	-.12	.14	-.11	.01
Visual Puzzles	-	-	-	-	-.52	.31	-.26	.02

Note. dash = variable not included on specific version of test. *p < .01. *B* = unstandardized coefficient; *SE B* = Standard error of unstandardized coefficient; β = Standardized coefficient; sr^2 = squared semipartial correlation; PC = Picture Completion; PA = Picture Arrangement; MR = Matrix Reasoning

regression and was able to significantly explain the variance in performance on the Trails B, $\Delta R^2 = .36$, *F* Change(10, 78) = 5.47, $p < .001$, over and above age and education, $R^2 = .49$, *F*(12, 78) = 6.28, $p < .001$. Tables 14 and 15 show the individual predictive values and confidence intervals for each predictor entered in both hierarchical regression

Table 13

Confidence Intervals for Unstandardized Regression Coefficients for Trails A Total Time

Variable	WAIS-III		WAIS-IV	
	99% Confidence Interval		99% Confidence Interval	
	Lower Limit	Upper Limit	Lower Limit	Upper Limit
Age	-.02	.34	-.02	.34
Education	-2.28	.06	-2.28	.06
Age	-.20	.18	-.21	.18
Education	-1.38	1.08	-1.20	1.11
Information	-.88	.88	-.69	.70
Digit Span	-.91	.50	-.50	.50
Vocabulary	-.27	.50	-.32	.46
Arithmetic	-1.23	.74	-1.66	.44
Comprehension	-.50	.91	--	--
Similarities	-1.35	.49	-.81	.40
Picture Completion	-1.41	.50	--	--
Picture Arrangement	-.59	1.00	--	--
Block Design	-.19	.34	-.17	.48
Matrix Reasoning	-1.03	.74	-.81	.40
Digit Symbol Coding	-.28	.08	-.42	-.02
Letter-Number Sequencing	-2.09	.50	--	--
Symbol Search	-.63	.17	-.50	.26
Visual Puzzles	--	--	-1.33	.29

Note. Dashes indicate that variable was not included on specific version of test

models. With an R^2 difference of .03 and a 99% confidence interval can ranging from -.035 to 0.88, the WAIS-IV was not shown to be a significantly better predictor of performance on Trails B. Since the WAIS-IV was not shown to be a significantly better

Table 14

Summary of Multiple Regressions for Variables Predicting Trails B Performance

	WAIS-III				WAIS-IV			
Variable	*B*	*SE B*	β	sr^2	*B*	*SE B*	β	sr^2
Age	.90	.28	.32*	.10	.90	.28	.32*	.10
Education	-4.61	1.86	-.25	.06	-4.61	1.86	-.25	.06
Age	.46	.30	.17	.01	.47	.31	.17	.00
Education	.66	1.94	.04	.00	-.19	1.83	-.01	.00
Information	-.17	1.38	-.02	.00	.13	1.10	.01	.00
Digit Span	-1.28	1.11	-.15	.01	-.28	.80	-.04	.00
Vocabulary	.87	.61	.24	.01	-.21	.62	-.05	.00
Arithmetic	-4.02	1.55	-.37	.04	-2.90	1.67	-.25	.02
Comprehension	.61	1.11	.08	.00	-	-	-	-
Similarities	-2.28	1.45	-.26	.02	-1.51	.96	-.20	.02
PC	-2.77	1.50	-.21	.02	-	-	-	-
PA	-.50	1.25	-.06	.00	-	-	-	-
Block Design	.87	.61	.24	.03	.86	.52	.27	.02
MR	-1.17	1.39	-.13	.01	1.18	1.14	.12	.01
Coding	-.11	.29	-.05	.00	-.74	.32	-.30	.04
LNS	-1.32	2.04	-.09	.00	-	-	-	-
Symbol Search	-.35	.63	-.08	.00	-.34	.60	-.08	.00
Visual Puzzles	-	-	-	-	-2.64	1.29	-.31	.03

Note. dash = variable not included on specific version of test. *p < .01. *B* = unstandardized coefficient; *SE B* = Standard error of unstandardized coefficient; β = Standardized coefficient; sr^2 = squared semipartial correlation; PC = Picture Completion; PA = Picture Arrangement; MR = Matrix Reasoning

predictor of performance on Trails B, the hypothesis was not supported.

Hypothesis 6

The sixth hypothesis stated that the subtests of the WAIS-IV would be better predictors of performance on the WCST, specifically in the number of errors, than would

Table 15

Confidence Intervals for Unstandardized Regression Coefficients for Trails B Total Time

Variable	WAIS-III		WAIS-IV	
	99% Confidence Interval		99% Confidence Interval	
	Lower Limit	Upper Limit	Lower Limit	Upper Limit
Age	.15	1.65	.15	1.65
Education	-9.50	.28	-9.50	.28
Age	-.33	1.26	-.34	1.29
Education	-4.45	5.78	-5.03	4.65
Information	-3.82	3.48	-2.77	3.03
Digit Span	-4.22	1.65	-2.39	1.82
Vocabulary	-.74	2.47	-1.84	1.42
Arithmetic	-8.12	.08	-7.29	1.50
Comprehension	-2.32	3.54	--	--
Similarities	-6.11	1.55	-4.04	1.01
Picture Completion	-6.73	1.19	--	--
Picture Arrangement	-3.82	2.81	--	--
Block Design	-.26	1.95	-.51	2.23
Matrix Reasoning	-4.85	2.51	-1.84	4.18
Digit Symbol Coding	-.87	.64	-1.58	.10
Letter-Number Sequencing	-6.72	4.07	--	--
Symbol Search	-2.01	1.31	-1.93	1.25
Visual Puzzles	--	--	-6.03	.76

Note. Dashes indicate that variable was not included on specific version of test

the WAIS-III. Tables 16 and 17 show the individual predictive values for each predictor entered in both hierarchical regression models as well as the confidence intervals. For both hierarchical regressions, the initial block of the hierarchical regressions contained age and education as predictors for WCST perseverative errors and were significant, R^2 =

Table 16

Summary of Multiple Regressions for Variables Predicting WCST Performance

	WAIS-III				WAIS-IV			
Variable	*B*	*SE B*	β	sr^2	*B*	*SE B*	β	sr^2
Age	.09	.03	.30*	.09	.09	.03	.30*	.09
Education	-.55	.19	-.30*	.08	-.55	.19	-.30*	.08
Age	.02	.03	.06	.00	.02	.03	.08	.00
Education	-.13	.21	-.07	.00	-.07	.20	-.04	.00
Information	-.16	.15	-.19	.01	.04	.12	.04	.00
Digit Span	.01	.12	.01	.00	.06	.09	.08	.00
Vocabulary	.06	.07	.17	.01	-.06	.07	-.13	.01
Arithmetic	.17	.17	.15	.01	.11	.18	.09	.00
Comprehension	.00	.12	.00	.00	-	-	-	-
Similarities	-.05	.16	-.06	.00	-.06	.10	-.08	.00
PC	.09	.16	.07	.00	-	-	-	-
PA	-.20	.14	-.22	.02	-	-	-	-
Block Design	-.04	.05	-.15	.01	.00	.06	.01	.00
MR	-.13	.15	-.14	.01	-.43	.12	-.43*	.10
Coding	-.05	.03	-.21	.02	-.03	.03	-.14	.01
LNS	-.10	.22	-.07	.00	-	-	-	-
Symbol Search	-.03	.07	-.07	.00	-.06	.06	-.14	.01
Visual Puzzles	-	-	-	-	-.01	.14	-.01	.00

Note. dash = variable not included on specific version of test. *p < .01. *B* = unstandardized coefficient; *SE B* = Standard error of unstandardized coefficient; β = Standardized coefficient; sr^2 = squared semipartial correlation; PC = Picture Completion; PA = Picture Arrangement; MR = Matrix Reasoning

.15, $F(2, 88) = 7.51$, $p = .001$. The second block of the first hierarchical regression contained the WAIS-III subtests and was significant, $\Delta R^2 = .28$, F Change(13, 75) = 2.81,

Table 17

Confidence Intervals for Unstandardized Regression Coefficients for WCST

Variable	WAIS-III		WAIS-IV	
	99% Confidence Interval		99% Confidence Interval	
	Lower Limit	Upper Limit	Lower Limit	Upper Limit
Age	.01	.16	.01	.16
Education	-1.03	-.06	-1.03	-.06
Age	-.07	.10	-.07	.11
Education	-.68	.43	-.59	.45
Information	-.56	.24	-.27	.35
Digit Span	-.31	.33	-.17	.28
Vocabulary	-.11	.24	-.23	.12
Arithmetic	-.28	.61	-.36	.58
Comprehension	-.32	.32	--	--
Similarities	-.47	.37	-.33	.21
Picture Completion	-.34	.52	--	--
Picture Arrangement	-.56	.17	--	--
Block Design	-.16	.08	-.14	.15
Matrix Reasoning	-.53	.28	-.75	-.11
Digit Symbol Coding	-.13	.04	-.12	.06
Letter-Number Sequencing	-.69	.49	--	--
Symbol Search	-.21	.15	-.23	.11
Visual Puzzles	--	--	-.38	.35

Note. Dashes indicate that variable was not included on specific version of test

$p = .003$, revealing a contribution over and above age and education, $R^2 = .43$, $F(15, 75) =$

3.71, $p < .001$. The second hierarchical regression contained the WAIS-IV subtests in the second block and was significant, $\Delta R^2 = .27$, F Change(10, 78) = 3.67, $p < .001$, indicating that the subtests contribute over and above education, $R^2 = .42$, $F(12, 78) = 4.69$, $p < .001$. With an R^2 difference of 0.07 and a 99% confidence interval ranging from -.03 to .04, the comparison was not significant. The confidence intervals can be found in Table 7. Neither model was a significantly better predictor of performance on the WCST than the other. The hypothesis was not supported.

Post-hoc Analyses

In reviewing the results of the analyses, it was determined that it would be beneficial to examine the Pearson correlations among the subtests for the WAIS-III and the WAIS-IV. The WAIS-III correlations are found in Table 18. For the WAIS-III, all

Table 18

Pearson Correlations between WAIS-III Subtests

	VC	CD	SM	BD	AR	MR	DS	IN	PA	CP	SS	LNS
PC	.33*	.42*	.45*	.57*	.42*	.57*	.34*	.36*	.61*	.34*	.51*	.44*
VC	-	.31*	.78*	.41*	.57*	.36*	.30*	.78*	.51*	.75*	.32*	.55*
CD		-	.37*	.56*	.50*	.52*	.50*	.34*	.46*	.27*	.73*	.47*
SM			-	.56*	.62*	.45*	.27	.72*	.60*	.73*	.45*	.48*
BD				-	.63*	.69*	.49*	.40*	.54*	.45*	.64*	.59*
AR					-	.57*	.49*	.61*	.45*	.62*	.56*	.60*
MR						-	.49*	.47*	.70*	.43*	.60*	.54*
DS							-	.22	.35*	.21	.51*	.70*
IN								-	.56*	.72*	.36*	.48*
PA									-	.48*	.43*	.50*
CP										-	.34*	.49*
SS											-	.57*

Note. * = $p \leq .01$. PC = Picture Completion; VC = Vocabulary; CD = Digit Symbol Coding; SM = Similarities; BD = Block Design; AR = Arithmetic; MR = Matrix Reasoning; DS = Digit Span; IN = Information; PA = Picture Arrangement; CP = Comprehension; SS = Symbol Search; LS = Letter Number Sequencing.

subtests were significantly correlated with the exception of Digit Span with Similarities, Information, and Comprehension. The WAIS-IV subtests correlations can be found in Table 19. Most of the subtests were highly correlated. The exceptions involve the Vocabulary and Information subtests. Vocabulary was not significantly correlated with Symbol Search or Coding, and Information was not significantly correlated with Symbol Search, Visual Puzzles, or Coding.

Table 19

Pearson Correlations between WAIS-IV Subtests

	SIM	DS	MR	VOC	AR	SS	VP	IN	CD
BD	.54*	.57*	.59*	.44*	.66*	.61*	.80*	.34*	.53*
SIM	-	.42*	.47*	.64*	.67*	.37*	.40*	.52*	.31*
DS		-	.45*	.47*	.56*	.52*	.51*	.31*	.45*
MR			-	.40*	.53*	.53*	.51*	.39*	.52*
VOC				-	.58*	.22	.29*	.73*	.21
AR					-	.47*	.55*	.54*	.48*
SS						-	.59*	..22	.72*
VP							-	.20	.45*
IN								-	.26

Note. * = $p \leq .01$. BD = Block Design; SIM = Similarities; DS = Digit Span; MR = Matrix Reasoning; VOC = Vocabulary; AR = Arithmetic; SS = Symbol Search; VP = Visual Puzzles; IN = Information; CD = Digit Symbol Coding.

CHAPTER V

Discussion

The current study aimed to examine the WAIS-IV and how the changes to the new version may impact the test's usefulness in neuropsychological evaluations. The purpose of the study was to examine the neuropsychological utility of the WAIS-IV compared to the WAIS-III and sought to determine if the WAIS-IV was more useful at predicting performance on neuropsychological measures than the WAIS-III.

Hypothesis 1

The first hypothesis stated that, based on the changes to the WAIS-IV proposing that the measure was more consistent with neuropsychological theory, the WAIS-IV would be a better predictor of performance on the Category Test than the WAIS-III. The hypothesis was not supported by the current analyses.

Changes to the WAIS-IV were believed to make the test a better measure that would be more closely related to neuropsychological measures and theory. In particular, the WAIS-IV contains fewer time bonuses and fewer motor demands, which can negatively impact neurologically impaired individuals unnecessarily. The most significant change that was expected to yield significant changes in the prediction of performance on the Category Test was the redesigning of subtests that was intended to produce a stronger association and perceived better measurement of fluid reasoning (i.e., ability to process/manipulate abstractions, rules, generalization, and logical relationships), which are strongly measured by the Category Test and used in higher order cognitive processing and executive skills. Not only did the designers of the WAIS-IV strive to make the PRI subtests better measures of fluid reasoning by diminishing motor demands and timed bonuses, a new subtest (i.e., Visual Puzzles) was added to the WAIS core battery in order to be a better measure and make an overall better index measure of perceptual reasoning/fluid reasoning/intelligence. These changes were expected to yield a greater neuropsychological utility of the WAIS-IV because of the focus on underlying cognitive principles and fewer extraneous variables that can impact raw scores and, subsequently, the achieved intellectual scores.

The hypothesis was proposed because of the addition of Visual Puzzles to the test, which, while a related nonverbal measure of intelligence, adds to the WAIS-IV over and above Block Design and Matrix Reasoning in that it assesses more of an integrative frontal, executive process than both Block Design and Matrix Reasoning. With the inclusion of a timed component to puzzle manipulation and spatial reasoning, the integrative features of Visual Puzzles were proposed to influence more frontal lobe functions over and above the other nonverbal tests from the WAIS-III in that the task requires frontal skills of hypothesis formation, mental flexibility, planning, problem solving, and conceptualization. Thus, the task requires more of the frontal lobe functions that the Category Test measures as opposed to simply the spatial relations of the Category Test that are more consistent with Block Design and the untimed problem solving of Matrix Reasoning.

The frontal lobes possess a group of abilities known as the executive skills, include attention, reasoning, judgment, problem solving, creativity, emotional regulation, impulse control, and awareness of one's functioning (Scott & Schoenberg, 2011). Luria (1973) discussed the simple to complex processes involved in higher order executive skills that are produced in the frontal lobes. According to Luria (1973), the frontal lobes are responsible for the regulation of complex intellectual processes and voluntary attention. Visuoconstruction, visual reasoning, and problem solving, as measured by Block Design and Matrix Reasoning, are some nonverbal abilities partially assessed by the frontal lobes. The perception of shapes as assessed in Block Design, Matrix Reasoning, and Visual Puzzles is an active process, which requires the individual to search for the most important elements of information, compare them, create an hypothesis concerning the meaning of the design as a whole, and then verify the hypothesis by comparing it with the original elements of the objects or designs seen.

Exceeding these shared aspects of the three PRI subtests of the WAIS-IV, the new subtest addition of Visual Puzzles was designed to assess the more complex and integrated abilities of executive skills that are more heavily influenced by frontal lobe functioning and requires the individual to develop and test hypotheses based on given rules under timed constraints. The test replaced the former subtest of Picture Completion of the WAIS-III, which was not as highly correlated with Category performance or other executive measures and tended to rely more on visual attention. Visual Puzzles was expected to be a measure of integrated functional lobe functioning. The integrated process taps frontal lobe functions used when an individual must test and develop hypotheses. Individuals with frontal lobe conditions are more likely to exhibit impulsive, fragmentary guesses as opposed to intellectual activity and hypothesis testing required to adequately complete the activity with the given set of rules and criteria (Luria, 1973). Visual Puzzles, like Category, requires the individual to understand the given material, distinguish the details of the designs, compare them, formulate an hypothesis of the designs, and test the hypothesis with the given set of rules in order to evaluate the hypothesis and further resume the analysis of the designs. This program of analysis and synthesis requires switching from various operations and hypotheses, which can be disrupted with frontal lobe conditions (Luria, 1973). Individuals with frontal lobe conditions have difficulty switching and testing hypotheses and are easily distracted, making it difficult for them to perform the correct analysis and synthesis of material to generate and test hypotheses to complete the tasks. This produces inflexibility in the problem solving approach, as they are often unaware of their mistakes and unable to correct them (Luria, 1973). The process of forming and executing a program is difficult for individuals with frontal lobe lesions, as they are unable to first analyze the component elements of the given conditions, formulate a definite strategy and then compare the results with the original conditions given in both the Visual Puzzles subtest and the Category Test. For less complex tests with simple and unambiguous solutions, these individuals may not show significant difficulties (e.g., Matrix Reasoning and Block Design), as the process is not as complex and the approach is not as integrated as Visual Puzzles and the Category Test.

Based on this more integrative process as well as the more integrative process of the Category task, it would be expected for the new subtest to add more predictive ability to the performance on the Category Test over and above Block Design and Matrix Reasoning, which contain less integrated assessments of executive skills and are less frontal in nature and more spatially oriented. Despite these similarities and the focus towards a more integrated measure of frontal lobe functioning and executive abilities, the current analyses do not support the hypothesis. The Visual Puzzles subtests did not significantly add to the predictive ability of the WAIS-IV over and above the WAIS-III nonverbal subtests.

While Visual Puzzles and the Category Test do tap similar integrative abilities, the two tests are not without their differences. The Category Test contains multiple components that range from simple knowledge of roman numerals to visual discrimination, spatial reasoning, working memory/simple arithmetic, and a memory component that assesses the ability to recall previously seen problems. These multiple components set the test apart from Visual Puzzles that assesses a more straightforward integrated process of hypothesis testing and problem solving with puzzles.

Not only was the Visual Puzzles test expected to make the newest version of the WAIS more consistent with the Category Test but the WAIS-IV was designed to be a stronger measure of working memory, which is another ability tapped by the Category Test. Working memory is assessed through two subtests of the Category Test through the assessment of simple arithmetic. On the WAIS-III and WAIS-IV working memory is assessed through two subtests of Digit Span and Arithmetic. The WAIS-IV was designed to be a better measure of working memory (ability to actively maintain information and mentally manipulate it in order to produce a result). The digit span subtest was redesigned to decrease rhyming numbers and a sequencing portion was added that requires the individual to perform a more complex working memory task than the previous version of Digit Span that contained only forwards and backwards. Changes were made to the Arithmetic subtest to make instructions and problems clearer as well as decrease the impact of timed bonuses. The test is associated with frontal lobe functions and working memory, as the individual must analyze the given information and then develop a strategy to solve the problems. For more simple problems, individuals with a frontal lobe condition would be unlikely to show difficulty. As the problems become more difficult, as seen in the progressive difficulty in the Arithmetic subtest, the nature of the test changes, becoming a higher load measure of working memory and an executive process of analysis and problem solving (Luria, 1973). These changes are relevant to performance on the Category Test, as parts of the test are strongly related to and directly require working memory skills to mentally manipulate minor mathematical information. Despite these changes that were proposed to make the test a better predictor of performance on the Category Test, the current results show that the WAIS-IV was not a significantly better predictor of performance on Category errors than the WAIS-III.

Further examination of the relationship between the two versions and the Category Test revealed there were observed differences in the most significant predictors of Category errors performance for the different versions of the WAIS. For the WAIS-III, the Arithmetic subtest was the only significant predictor of performance on the Category Test. This finding makes sense, considering that two subtests of the Category Test involve fractions, mental arithmetic, and working memory. In contrast, the WAIS-IV subtest that was the most significant predictor of performance on the Category Test was WAIS-IV Coding. While WAIS-IV Coding is not necessarily an executive functioning measure, the task does involve processing speed, visual scanning, and visual discrimination, required to transcribe numbers quickly. Components of the Category Test require visual discrimination in order to find the most different object and correctly identify missing quadrants. The WAIS-IV Arithmetic subtest was not a significant predictor of performance on the Category Test.

The differences are of interest because, while both processing speed and working memory are components of higher order cognitive functions like those measured by the Category Test, the two subtests assess different properties. The ability to mentally manipulate information (i.e., working memory), as that required for the Arithmetic subtest, is fundamentally different than the Coding subtest that assesses speeded visual discrimination and visual scanning (i.e., processing speed). Changes made to the Arithmetic subtests from the WAIS-III to the WAIS-IV dealt with fewer timed bonuses and clearer administration instructions. Changes in the Digit Symbol Coding/Coding subtest from the WAIS-III to the WAIS-IV were strictly in the symbols themselves and in the administration directions. It was expected that the new Visual Puzzles subtest of the WAIS-IV and the WAIS-IV subtests as a whole would be significantly better predictors of performance, which was not supported and leads to the conclusion that the changes in the WAIS do not result in better prediction of performance on Category errors.

Additionally, Pearson correlations were examined to further assess the relationship between the two versions of the WAIS and performance on Category errors. For the WAIS-III, all of the subtests had significant negative correlations with performance on Category errors, indicating that as the raw scores for the subtests increased (i.e., performance improved) the number of Category errors decreased, indicating better performance on the Category Test. Thus, as performance on intellectual subtests measures increased, fewer Category errors were made.

The WAIS-III subtest most highly correlated with performance on Category errors was Block Design, which would be expected considering that Block Design is a measure of visuospatial reasoning and nonverbal problem solving, similar to the Category Test. The Symbol Search subtest was the next highest correlated subtest, which likely shows the relationship between visual discrimination used with both the subtest and the Category Test. Arithmetic was the next most highly correlated WAIS-III subtest with Category errors, showing the use of working memory and simple arithmetic used for the subtest and the Category Test. The WAIS-III Matrix Reasoning subtest had the fourth highest correlation with Category errors. The subtest assesses fluid reasoning and includes nonverbal, visuospatial problem solving, and it is considered a strong measure *g*. It would be expected to be strongly related to the Category Test, which is a measure of fluid reasoning and problem-solving. The remaining order of significant WAIS-III subtest correlations with performance on the Category Test was as follows: Picture Completion, Picture Arrangement, Digit Symbol Coding, Letter Number Sequencing, Similarities, Digit Span, Comprehension, Vocabulary, and Information.

Due to the nonverbal nature of the Category Test, it would be expected for the verbal subtests of Similarities, Comprehension, Vocabulary, and Information to be the least related to the test. Picture Completion and Picture Arrangement require nonverbal reasoning and visual attention. Thus, the two tests would be expected to be related to the Category Test. The results of the correlation analyses support the justification in removing these test from the core battery in the case of picture completion and in removing picture arrangement from the tests, as the tests were not as strongly correlated with fluid reasoning abilities as the other fluid reasoning measures of the Block Design and the Matrix Reasoning subtests. The order of the verbal WAIS-III measures was not surprising, since Similarities and Comprehension require more abstraction, even verbally, than Vocabulary and Information. Digit Span being less correlated as the other working memory subtest of Arithmetic was not surprising, since the Arithmetic subtest shares simple arithmetic skills like the Category Test as well as being a higher load working memory measure requiring more mental manipulation of information.

For the WAIS-IV, the highest correlated subtest was Visual Puzzles, which is a new subtest to the WAIS and designed to make the test a better measure of frontal, executive skills. Thus, it was not a surprise that it was strongly correlated with performance on the Category Test. The next most highly correlated WAIS-IV measure with performance on Category errors was the Block Design subtest, a similar measure assessing parallel abilities. The third most highly correlated subtest was the WAIS-IV Coding subtest, assessing visual discrimination and processing speed, a component of higher order cognitive processing. The WAIS-IV Matrix Reasoning subtest was the fourth most highly correlated test with performance on the Category Test, showing the fluid reasoning relationship and measurement of each test. The remaining order of significantly correlated subtests was Arithmetic, Symbol Search, Digit Span, Similarities, Vocabulary, and Information. As noted in the earlier discussion with the WAIS-III correlations, the Arithmetic subtest taps similar abilities to two subtests of the Category measure and the significant correlation was not surprising. It was not surprising that the verbal measures were the least correlated with Category performance, with Similarities being more highly correlated due to the use of verbal abstraction, a more complex and higher order process despite being verbal in nature.

The observed differences in the correlations shows that, as would be anticipated, the fluid reasoning and executive skills measures are strongly related to the Category Test and higher order cognitive abilities such as problem solving, hypothesis testing, reasoning, and pattern finding. Additionally, the correlations show that processing speed measures and mental arithmetic (i.e., mental manipulation/working memory) are strongly related to executive abilities. Digit Span from the WAIS-III as well as Digit Span from the WAIS-IV were not as strongly correlated as might be expected, given the working memory component of the measures. A new sequencing component was added to the WAIS-IV Digit Span subtest, as a proposed way to make a higher load working memory measure. The results of the correlation analyses indicate that the sequencing component of the WAIS-IV Digit Span subtest did not add to the neuropsychological utility of the measure, in that the measure does not appear to be any more highly related to the Category Test, which requires an amount of working memory abilities for a portion of the test, than the WAIS-III version with only forward and backward digit span. While the hypothesis was not supported, the order of significant correlations for the WAIS-IV shows that the changes to the WAIS-IV did result in closer relationships with the subtests proposed to measure fluid reasoning and a widely used neuropsychological measure of fluid reasoning.

With the changes to the WAIS-IV, it would be expected that the PRI subtests of Block Design, Matrix Reasoning, and Visual Puzzles as well as the WMI subtests of Digit Span and Arithmetic would be more highly correlated with the Category Test than the WAIS-III subtests of Block Design, Matrix Reasoning, and Picture Completion. The results of the Pearson correlation comparisons shows that both the PRI subtests and WMI subtests of the WAIS-IV are not more highly correlated with performance on the Category Test as those on the previous version of the WAIS, despite the proposed changes to make the subtests more consistent with fluid reasoning, frontal lobe functioning, and working memory.

Hypotheses 2 and 3

The second and third hypotheses theorized that the WAIS-IV would be a better predictor of performance on the FTT for the dominant and non-dominant hands over the WAIS-III. Changes made to the WAIS-IV were proposed to make the test a better measure of processing speed, which led to the hypothesis that the WAIS-IV would be a better predictor of performance on FTT, a measure of psychomotor speed and reaction time, considered to be components of processing speed. The WAIS-IV was designed to reduce motor demands, which would be expected to make it have a stronger negative predictive relationship with FTT, a purer measure of motor speed. The hypothesis was not supported by the current analyses.

The FTT dominant hand and non-dominant hand are measures of psychomotor speed. Particularly, the FTT dominant hand performance is often used as a measure of pure psychomotor and reaction speed over the non-dominant hand. This is due to the fact that most individuals are more adept with their dominant hand. Scores for the dominant hand are expected to be about 10% faster than the non-dominant hand (Golden, et al., 2000). Thus, the FTT dominant hand would be expected to be slightly more related to measure of speeded processing and reaction time than the non-dominant hand FTT performance.

The FTT was proposed to be better predicted by the newest version of the WAIS, due to the changes alleged to make the test more consistent with neuropsychological theory and a better measure of processing speed. Psychomotor speed is a component of processing speed that assesses the speed of movements like that required with rapid fingertip manipulations and sustained speed over brief periods of time, as assessed with the finger tapping task.

Slowed psychomotor movements are observed in neurological populations after brain injury, stroke, as well as individuals with diagnoses of schizophrenia, multiple sclerosis, and Parkinson's disease. The frontal lobe is responsible for simple and complex motor skills as well as sequenced motor skills (Luria, 1973). In addition, Luria (1973) states that the foundation for the configuration of voluntary movement and conscious action takes place in the frontal lobe, where the movement formulates, the action preservation takes place, and the performance of the action is regulated and monitored. All motor movements require some planning and goal selection from the executive skill set. While mostly accepted as a measure of pure psychomotor speed, without significant influence of higher order cognitive skills, some classify processing speed in three different domains of motor speed, visual-perceptual speed, and visual-motor integration (Suchy, Eastvold, Strassberg, & Franchow, 2014). Often, the dominant hand finger tapping performance is accepted as a pure measure of psychomotor speed, a simple response time task (Kennedy, Clement, & Curtiss, 2003). The PSI measures of the WAIS are accepted as measures of speed of responding to simple content (Kennedy et al., 2003).

The WAIS-IV was also designed to cut down on the motor demands that could impact performance in neurologically impaired populations. The changes to Symbol Search for the WAIS-IV include larger stimuli and the individual marks the matching symbol or the NO box as opposed to marking a YES or NO box as with the WAIS-III. These changes are proposed to have fewer motor and visual demands. The Coding subtest of the WAIS-IV saw changes to the symbols as well as larger stimuli, believed to decrease visual and motor demands. With each processing measure still having an obvious motor component involved in writing, it would be expected that there would still be a relationship between the measures. Thus, it would be expected that the WAIS-IV would be a better predictor of performance on the FTT due to an inverse relationship, with fewer motor demands leading to an inverse relationship with the FTT, but a better predictive power than the WAIS-III, which has not shown a close relationship with the FTT.

It was also expected that the Block Design subtest would have a relationship with the FTT because the test requires manual manipulation of blocks in order to make the designs. The changes made to the subtest for the WAIS-IV included larger stimuli and decreased timed bonuses, lessening the speeded component of the test. Thus, the relationship would be expected to have an inverse relationship, as the measure likely is less influenced by psychomotor speed but continues to maintain a motor component.

The analyses showed that the WAIS-III was not a significant predictor of dominant hand performance for the FTT. In contrast, the WAIS-IV was able to significantly predict dominant hand performance on the FTT. Despite the WAIS-IV showing a significant model of prediction for FTT dominant hand performance while the WAIS-III did not, the difference between the models was not statistically significant. Thus, the WAIS-IV was not a statistically significant better predictor over and above the WAIS-III.

For the FTT dominant hand, further examination of the relationship between the two versions revealed that there were no observed differences in the most significant predictors of FTT dominant hand performance in the regression models for the different versions of the WAIS. For the WAIS-III, the overall regression was not significant and no analysis of the individual predictors can be conducted. For the WAIS-IV overall regression was significant, but none of the individual predictors significantly predicted performance on FTT with the dominant hand over and above the other predictors in the regression model.

Pearson correlations were examined to further assess the relationship between the two versions of the WAIS and FTT dominant hand performance. All of the WAIS-III subtests had positive correlations with FTT dominant hand performance, indicating that as the raw scores for the subtests increased (i.e., performance improved) the number of taps performed by the dominant hand increased, showing better performance on the FTT dominant hand. As performance on intellectual subtests measures increased, FTT dominant performance increased.

For the WAIS-III, only Symbol Search, Block Design, Letter Number Sequencing, Digit Symbol Coding, and Picture Completion were significantly correlated with FTT dominant hand performance. Symbol Search being the most highly correlated with FTT dominant hand performance was not surprising considering that the test has a motor and processing component. Block Design's strong motor component that requires manipulation of blocks in the construction of the design reveals a relationship between the two tasks. Letter Number Sequencing being highly correlated with FTT dominant hand performance was surprising, considering the working memory component of Letter Number Sequencing, which appears to have little relation to the motor/processing components of FTT dominant hand performance. There was evidence of an underlying relationship between working memory and processing speed. The relationship may have something to do with a reaction time component involved in both FTT dominant hand performance and Letter Number Sequencing, in that increased reaction time improves performance on both tasks. Digit Symbol Coding being the next most significantly correlated measure with FTT dominant hand performance was not surprising considering the measure is a processing speed measure with a motor component required in the transcription of the symbols. Picture Completion being the final significantly correlated measure with FTT dominant performance was not surprising, considering there can be a motor component involved in the task, as the individual is allowed to point to the missing part of the picture as opposed to only naming the missing part. The remaining order of non-significant WAIS-III subtest correlations with FTT dominant hand performance was as follows: Picture Arrangement, Arithmetic, Matrix Reasoning, Digit Span, Similarities, Vocabulary, Comprehension, and Information. These non-significant correlations are not surprising considering the lack of abstract reasoning or problem solving involved in completing FTT with the dominant hand. Due to the nonverbal and motor dependent nature of the FTT, it would be expected for the verbal subtests of Similarities, Comprehension, Vocabulary, and Information to be the least related to the test.

For the WAIS-IV, all of the subtests had positive correlations with FTT dominant hand performance. Thus, as performance on intellectual subtests increased, FTT dominant performance increased. Only Visual Puzzles, Block Design, Coding, and Digit Span were significantly correlated with FTT dominant hand performance.

The highest correlated WAIS-IV subtest was Visual Puzzles, which is a new subtest to the WAIS and designed to make the test a better measure of frontal, executive skills. While the FTT is not necessarily a measure of executive skills, it was not a surprise that Visual Puzzles was strongly correlated with FTT dominant hand performance, as simple motor skills are partially controlled and accommodated by the frontal lobes (Luria, 1973). The next most highly correlated WAIS-IV measure with FTT dominant hand performance was the Block Design subtest, a timed motor dependent measure, as described earlier. As described in the WAIS-III FTT dominant hand discussion, it was not surprising that the measure was significantly related to FTT dominant hand performance. The third most highly correlated subtest was the WAIS-IV Coding subtest. The high correlation observed was not surprising considering the subtest shares some similar characteristics with FTT performance with the dominant hand. The Coding subtest assesses processing speed, with a graphomotor component required in the transcription of symbols, which would be an element of the skills assessed by performance on FTT with the dominant hand. The WAIS-IV Digit Span subtest was the fourth most highly correlated test with FTT dominant hand performance, again, showing the relationship with the two measures and reaction time. The remaining order of non-significantly correlated subtests was Arithmetic, Symbol Search, Matrix Reasoning, Similarities, Vocabulary, and Information. The analysis of the correlations shows that Symbol Search was not significantly related to FTT dominant hand performance, which was of interest considering the processing component of the test as well as the motor dependent functions of the test. It was not surprising that Arithmetic and Matrix Reasoning were not significantly correlated with FTT dominant hand performance, as the FTT does not assess problem solving or executive skills nor does it require visuospatial skills or verbal abilities to complete the task.

The observed differences in the correlations show that there are only minor differences in the relationship between FTT dominant hand performance and the processing and motor dependent measures of the WAIS-III and WAIS-IV. Neither the WAIS-III or the WAIS-IV subtests showed more significant relationships with FTT dominant hand performance and the correlation values were not substantially different for either version of the test. It does not appear that the changes to the subtests greatly changed the relationship with motor speed or reaction time, as measured by a neuropsychological measure.

Visual Puzzles had the highest value and was the most highly correlated subtest with FTT dominant hand performance across the WAIS-III and the WAIS-IV. These high correlations with the new subtest on the WAIS-IV likely shows the tests relationship with frontal lobe functioning, which mediates motor functions as well as the strong reaction time component, as Visual Puzzles has a timed component, which obviously influences individuals performance on the task similar to FTT dominant hand. While both processing speed measures of Symbol Search and Coding were significantly correlated for the WAIS-III, only Coding was significantly correlated for the WAIS-IV. This is likely explained by the proposed decrease in motor demands and motor processing for Symbol Search on the WAIS-IV. It should be noted that none of these differences in correlations are substantial differences in correlation values. Working memory measures revealed significant correlations for dominant performance on the FTT, such as Letter Number Sequencing on the WAIS-III and Digit Span on the WAIS-IV. It is believed that the reaction required in these tasks is responsible for the observed relationships.

With the changes to the WAIS-IV, it would be expected that the PSI subtests of Coding and Symbol Search as well as the PRI subtest of Block Design would be more highly correlated with dominant hand performance on the FTT than the WAIS-III subtests of Symbol Search and Digit Symbol Coding and the PRI subtest of Block Design, due to the decreased motor demands and an increased relationship to processing speed. The results of the Pearson correlation comparisons had surprising findings of the highest correlations with dominant hand performance on FTT being Visual Puzzles. The next highest correlations of Block Design and Coding were more expected than the Visual Puzzles outcome with the dominant hand FTT performance. Both measures contain motor and timed components and were expected to be more strongly correlated with dominant hand performance on the FTT.

There was a lack of a significant relationship between Symbol Search and performance on the WAIS-IV. The WAIS-III Symbol Search subtest was significantly correlated with dominant hand performance on the FTT. While the differences are not significant, qualitatively the differences in the relationship between the WAIS-IV Symbol Search and the WAIS-III Symbol Search did meet the goal of eliminating motor demands on the subtest. The Coding subtest continues to be significantly correlated with the FTT for both the WAIS-III and WAIS-IV and had a higher correlation with the WAIS-IV, meaning that the measure continues to have higher motor demands.

In regards to the analyses for the non-dominant hand performance on the FTT, the analyses showed that the WAIS-III was not a significant predictor of non-dominant hand performance for the FTT. The regression model with the WAIS-IV subtests was able to significantly predict non-dominant hand performance on the FTT. Despite the WAIS-IV regression model showing significance when the WAIS-III model did not, the WAIS-IV regression model was not a statistically significant better predictor over the WAIS-III for non-dominant hand performance on the FTT. These findings are consistent with the findings with the FTT dominant hand.

For the FTT non-dominant hand, further examination of the relationship between the two versions revealed that there were no observed differences in the most significant predictors of FTT non-dominant hand performance in the regression models for the different versions of the WAIS. For the WAIS-III, the overall regression was not significant and no analysis of the individual predictors was conducted. For the WAIS-IV, the overall regression was significant, but none of the individual predictors significantly predicted performance on FTT with the non-dominant hand over and above the other predictors in the regression model.

Pearson correlations were examined to further assess the relationship between the two versions of the WAIS and FTT non-dominant performance. For the WAIS-III, all of the subtests had positive correlations with FTT non-dominant performance with the exception of Comprehension, which had a small negative correlation with FTT non-dominant performance. The observed correlations showed that for all subtests, except Comprehension, as the number of non-dominant hand taps increased on the FTT the raw scores on the subtests increased. Thus, better performance by the non-dominant hand on the FTT led to better performance on all subtests, except Comprehension. For the Comprehension subtest, as FTT non-dominant hand performance increased performance on Comprehension decreased.

The only significant correlations with WAIS-III and FTT non-dominant performance were Symbol Search and Digit Symbol Coding. This finding of significant correlations between the two processing speed measures with motor processing components was what would be expected with FTT non-dominant performance, which is strictly associated with reaction time, motor speed, and motor performance. The order of the other non-significant correlations are as follows: Picture Completion, Block Design, Letter Number Sequencing, Digit Span, Picture Arrangement, Arithmetic, Matrix Reasoning, Similarities, Information, Vocabulary, and Comprehension. These non-significant correlations are not surprising, considering the lack of verbal skills tapped by non-dominant hand finger tapping. While Block Design contains a motor component, as can Picture Completion, these motor components are likely better assessed through FTT dominant hand performance over FTT non-dominant hand performance. The reasons for this include the fact that the dominant hand is likely used for Picture Completion as individuals are more likely to point with their dominant hand and motor speed itself does not play a role in the completion of the task. Picture Completion is a timed task and speeded processing and reaction time likely play a large role and are better assessed with FTT dominant hand performance.

For the WAIS-IV, all of the subtests were positively correlated with FTT non-dominant performance. As FTT non-dominant hand performance improved, performance on the subtests of the WAIS-IV improved. Only two of the subtests were significantly correlated with FTT non-dominant performance. The highest correlated WAIS-IV subtest was Visual Puzzles, which is a new subtest to the WAIS and designed to make the test a better measure of frontal, executive skills. The test does not contain a motor component, but it is likely that the relationship is linked to the frontal nature of motor initiation and movement. The next most highly correlated WAIS-IV measure with FTT non-dominant performance was the Coding subtest, assessing visual discrimination and processing speed, with a motor component required to transcribe the symbols. The remaining order of non-significantly correlated subtests was Block Design, Digit Span, Matrix Reasoning, Information, Similarities, Symbol Search, and Vocabulary. Similar to the WAIS-IV findings for the FTT dominant hand performance, it was surprising that the Symbol Search subtest of the WAIS-IV was not significantly correlated with performance on FTT non-dominant performance, which would be expected considering the processing nature and motor components of the task. The results likely show that the motor demands of the subtest were decreased, as was the goal of the design of the new Symbol Search subtest. It was not surprising that Arithmetic and Matrix Reasoning were not significantly correlated with FTT non-dominant hand performance, as the FTT does not assess problem solving or executive skills nor does it require visuospatial skills to complete the task and the subtests do not contain motor speed or motor components. It was not surprising that the verbal measures were the least correlated with FTT non-dominant hand performance, as there are no verbal abilities tapped by FTT.

The observed differences in the correlations show that for the WAIS-III the PSI subtest of Symbol Search and Coding were the only significantly correlated subtests with FTT non-dominant hand performance. Only Coding from the WAIS-IV PSI measures was significantly correlated with FTT non-dominant performance. It is likely that the changes made to the Symbol Search subtest met the goal of decreasing motor demands on the task. The WAIS-IV Coding subtest contains more motor demands that are required in the transcription of symbols. It should be noted that none of the observed differences in correlations were significant from the WAIS-III to the WAIS-IV and any discussion of difference reflect qualitative changes and discussion in the differences in the order or significant of correlations over significant differences in the correlations from one version to the other.

Visual Puzzles was the most highly correlated subtest with FTT non-dominant hand performance across the WAIS-III and the WAIS-IV. This could be due to the more integrated frontal component of the new subtest, which could show the frontal connection between motor movement initiation and Visual Puzzles. The finding was unexpected and warrants discussion, which is done below.

With the changes to the WAIS-IV, it would be expected that the PRI subtest of Block Design would be more highly correlated with non-dominant hand performance on the FTT, due to the motor demands involved in the task. The results of the Pearson correlation comparisons had surprising findings that the Block Design subtest of the WAIS-IV was not significantly correlated with FTT non-dominant hand performance. Both measures contain motor and timed components and Block Design was expected to be more strongly correlated with dominant hand performance on the FTT. The fact that the measure was not correlated with FTT non-dominant hand performance could be due to the decrease in the timed bonus, which may decrease the reaction time component of the task as well as the speed motor demands. The non-dominant hand performance on FTT is not as closely related to a pure measure of psychomotor speed as the dominant hand performance, which is usually higher than that of the non-dominant hand.

The differences between FTT dominant and non-dominant performance show that the FTT dominant hand performance bore a stronger relationship with measures of reaction time and psychomotor speed than the non-dominant hand, as would be expected. The FTT dominant hand performance showed significant relationships with Visual

Puzzles, Block Design, Coding, and Digit Span. In contrast, the non-dominant hand only had a significant relationship with Visual Puzzles and Coding.

An interesting finding was the significantly correlated relationship between performance with the dominant and non-dominant hand of the FTT with performance on the WAIS-IV Visual Puzzles subtest. The finding was not predicted, but as stated earlier, likely shows the frontal lobe activities assessed by the two tasks. It shows the importance of the speeded reaction time and speeded processing involved in both tasks. While the timed component of Visual Puzzles might not be expected to play a large role in performance on the task, these results show that reaction time and speed likely do play a role in performance on Visual Puzzles.

The WAIS-IV Symbol Search had a decrease in the size of the correlation from dominant hand performance to non-dominant hand performance. It may be assumed that this was due to the writing portion of Symbol Search that was only completed with the dominant hand. This would be expected to be true for Coding as well, but it was not. It could be that the Coding subtest, which actually had a slightly larger correlation with the non-dominant hand is less influenced by graphomotor speed and is more influenced by reaction time and general psychomotor speed, as shown by performance with the non-dominant hand.

The dominant and non-dominant analyses of FTT show that the attempts to decrease the motor demands for Symbol Search on the WAIS-IV appear to have been successful. The WAIS-IV Symbol Search subtest was not significantly correlated with FTT performance with the dominant or non-dominant hand, as to where the WAIS-III version of the subtest was significantly correlated with both the dominant and non-dominant hand performance on the FTT. There was not a substantial change in the size of the correlations from WAIS-III to WAIS-IV but the lack of a significant relationship was note worthy. It would appear that there was not a significant decrease in the motor demands required for the WAIS-IV Coding, as the subtest was significantly related to FTT dominant and non-dominant hand performance. It was significantly correlated with both FTT components for the WAIS-III, with very little change in the magnitude of the correlation from the WAIS-III to the WAIS-IV.

Hypothesis 4

The fourth hypothesis stated that performance on the WAIS-IV subtests would be a better predictor of performance on Trails A than performance on the WAIS-III subtests. Changes made to the WAIS-IV were proposed to make the test a better measure of processing speed, thus leading to the hypothesis that the WAIS-IV would be a better predictor of performance on Trails A, a measure of visual scanning and processing speed. The hypothesis was not supported by the current analyses.

Processing speed is defined as the ability to process information quickly (Lichtenberger & Kaufman, 2013). It is thought to be a complex construct that plays a pivotal role in higher level cognitive functioning. Impairments in processing speed can result in impairments in other areas of cognitive abilities (O'Brien & Tulsky, 2008). Processing speed is typically measured by tasks of timed psychomotor performance and reflects an individual's cognitive efficiency and ability to perform simple psychomotor tasks quickly and efficiently. The processing speed subtests of the WAIS-IV were designed to measure processing speed in a nonverbal format. The primary constructs assessed by the processing speed tasks of the WAIS are visual processing speed, motor processing speed, and visual-motor processing speed (Lichtenberger & Kaufman, 2013). There are additional constructs that influence performance on processing speed measures that include visual discrimination, visual attention, sustained attention, memory, and understanding instructions (Golden et al., 2000). These tests of processing speed are influenced by motor impairment, difficulties concentrating and understanding instructions, anxiety and depression, hyperactivity, motivation, fatigue, and low frustration tolerance (Golden et al., 2000).

The WAIS-IV PSI is made up the two subtests, Coding and Symbol Search. The Coding subtest measures the individual's ability to quickly and accurately scan and sequence simple visual information. The subtest may be influenced by short-term visual memory, attention, or visual-motor coordination. The Coding subtest of the WAIS is much more likely to be influenced by graphomotor skills than the Symbol Search subtest of the WAIS, due to the transcription of symbols as opposed to making simple marks over symbols or boxes. Symbol Search requires an individual to scan target symbols and a set of symbols to find if there are is a target symbol that matches a symbol displayed in the set of symbols provided to the right of the target symbols. The measure requires speed and accuracy as well as visual scanning. The Symbol Search subtest can be influenced by visual discrimination and visual-motor coordination (Lichtenberger & Kaufman, 2013).

In order to make the processing measures clearer measures of processing speed, as well as making other measures less dependent on processing speed, timed bonuses were reduced and graphomotor and motor demands were reduced for the WAIS-IV. Other changes to the PSI subtests include bolder and larger symbols designed to reduce visual concerns. For Symbol Search, the examinee now marks the symbol as opposed to a

"YES" box, which provides a qualitative examination of errors made by the examinee. For the Coding subtest, there is larger vertical space between the key and top of the page in order to decrease issues with left-handed examinees blocking the key from their view while completing the task. The numbers were randomized and appear an equal number of times across each row, ensuring an equal exposure to each paired number and symbol. Like Symbol Search, the numbers and symbols are presented in a bolder fashion, decreasing issues with visual acuity. The instructions involved in the WAIS-IV processing speed subtests emphasize a greater degree of teaching than the WAIS-III. All individuals are taught to complete the subtests in the same manner, in order to decrease the impact of individual learning differences and comprehension difficulties that can impact performance on processing speed measures (Raiford, Coalson, Saklofske & Weiss, 2010).

Similar to the processing speed measures of the WAIS-III and WAIS-IV, Trails A is a measure of visual scanning and processing speed, with a graphomotor component that requires the individual to draw lines connecting the numbers 1 through 25 in sequential order as quickly as possible. The measure requires an individual to recognize numbers and scan the page continuously to indentify the sequence of the numbers under the pressure of time. Poor performance on Trails A is generally due to difficulties with motor speed or visual scanning. It would be expected that performance on Trails A would be predicted by the processing measures on the WAIS. Specifically, since the WAIS-IV is designed to be a purer measure of processing, it would be expected that the WAIS-IV would be a better predictor of Trails A performance than its predecessor.

It was expected that the WAIS-IV subtest of Digit Span would be a better predictor of performance on Trails A, due to changes to the test from the previous version. For the WAIS-IV, a sequencing component was added to the subtest to make it a higher load working memory measure. The change was expected to show a stronger relationship with Trails A, which has a mental sequencing, as the individual is required to sequence numbers in order to complete the task.

While Trails A and the processing measures of WAIS-IV and the Digit Span subtest of the WAIS-IV have similarities, the tests have some differences. Trails A has less of a graphomotor component and fewer motor demands, as the task only requires drawing lines to numbers in sequential order as opposed to the transcription of symbols required for the WAIS-IV Coding subtest. Trails A has less of a visual discrimination and visual attention component than the WAIS-IV Symbol Search subtest, because the individual is only required to visually scan for numbers as opposed to scan and attend to differences in symbols that sometimes include more subtle differences. While the sequencing component of the WAIS-IV Digit Span subtest may tap similar abilities as the sequencing involved in Trails A, the sequencing component of Digit Span requires the individual to attend to the numbers heard and mentally put them in sequential order. These numbers that the individual hears during the Digit Span subtest are not in natural order and are often numbers repeated, unlike Trails A that requires the individual to simply go from 1 to 25 in sequential order and are provided visually.

The results of the current analyses show that, while both versions of the WAIS are able to significantly predict performance on Trails A, there are differences in subtests that significantly predict performance on the measure. For the WAIS-III, no one subtest was able to significantly predict performance on Trails A over and above the other subtest and age and education. For the WAIS-IV, Coding was able to significantly predict performance on Trails A over and above the other subtest and age and education. It would appear that the changes made to the Coding subtest on the WAIS-IV does make the subtest a better measure of processing speed and more consistent with a traditionally used neuropsychological measure of processing speed. The lack of significant predictive ability shown for Symbol Search leads to questions regarding the utility of the measure as an assessment of processing speed and the utility of the changes made to make the measure more consistent with neuropsychological measures of processing speed.

In order to further evaluate the two versions of the WAIS and how these changes impact the relationship between the subtests of both versions and Trails A, Pearson correlations were examined to further assess the relationship. For all of the WAIS-III subtests, there was a significant negative correlation with performance on Trails A, with the exception of Comprehension, which had a negative correlation that was not significant. The negative correlations show that as time to complete Trails A increased raw scores on the subtests of the WAIS-III decreased, meaning that poorer performance on Trails A related to poorer performance on the WAIS-III subtests. The order of the correlations showed that Symbol Search was the most highly correlated subtest with Trails A performance, followed by Digit Symbol Coding, Letter Number Sequencing, Digit Span, Arithmetic, Block Design, Matrix Reasoning, Picture Completion, Similarities, Picture Arrangement, Information, and Vocabulary.

These correlations show that the relationship between the subtest of the WAIS-III and performance on Trails A are what would be expected, with the processing speed subtests the most significantly correlated with performance on Trails A. The third, fourth, and fifth most significantly correlated subtests with performance on Trails A were subtests linked with working memory, which likely shows a relationship to Trails A in that the measure requires keeping track of a running string of numbers while completing the task. The results also show the close working relationship between working memory and processing speed. The remaining order of the correlations was not surprising considering that Trails A does not contain a significant visuospatial or problem solving component like Block Design and Matrix Reasoning. There was not a substantial verbal component to the test and the verbal subtests of the WAIS-III would not be expected to be as highly correlated with the measure. Picture Completion was the eighth most highly correlated test with performance on Trails A. It would be expected that the visual attention component under the pressure of time required to complete the subtest might make it more highly correlated with the Trails A than was found in the analyses. The finding is likely due to the more complex nature of the visual attention involved in Picture Completion.

For the WAIS-IV, all subtests revealed significant negative correlations with performance on Trails A, with the exception of the Vocabulary and Information subtests that were negatively correlated but were not statistically significant. These correlations show that as performance on Trails A became poorer so did performance on the subtests of the WAIS-IV. Thus, as time to complete Trails A increased, raw subtest scores decreased. The most highly correlated subtest for performance on Trails A was Coding, followed by Symbol Search, Arithmetic, Visual Puzzles, Block Design, Matrix Reasoning, Similarities, and Digit Span.

Similar to the findings with the WAIS-III, it was not surprising that the processing speed subtests were the most highly correlated with Trails A performance. The working memory subtest of Arithmetic was highly correlated with performance on Trails A, which was not surprising considering the close relationship between working memory and processing speed, as well as the working memory component required for completion of Trails A through mentally sequencing numbers. Digit Span was not as highly correlated and was the lowest significant correlation. This was surprising considering the sequencing component added to the subtest and was expected to make the measure more closely related to performance on Trails A, a measure that requires sequencing of numbers. The lack of a high relationship between the two tests could show the difference between the auditory and visual formatting of the two measures. The remaining order of the correlations was not surprising considering that Trails A did not contain a significant visuospatial or problem solving component like Visual Puzzles, Block Design and Matrix Reasoning. There was no real verbal component to the test and the verbal subtests of the WAIS-IV would not be expected to be as highly correlated with the measure.

While the results of the analyses did not show a significant difference in the overall predictive abilities of the WAIS-IV over the WAIS-III, there were differences in the contribution of individual subtests, as Coding was able to significantly predict performance over and above the other variables in the model. There were no substantial differences in the correlation between the subtests of the WAIS-III and Trails A and the WAIS-IV and Trails A. Thus, the changes to the WAIS-IV did not significantly change the relationship between the subtests and performance on Trails A.

Hypothesis 5

For performance on Trails B, hypothesis five hypothesized that the WAIS-IV model would be a significantly better predictor of performance on the task over the WAIS-III model. Based on the changes to the WAIS-IV that included a stronger measure of processing speed, a more integrated measure of frontal lobe functioning in Visual Puzzles, and a higher load working memory component, in particular, a sequencing component on Digit Span, it was expected that the WAIS-IV would be a better predictor in performance for Trails B. The hypothesis was not supported by the current analyses.

Trails B is a test that assesses cognitive flexibility, set shifting, sequencing ability, and visual-motor tracking, while having a substantial attentional and inhibition component. Processing speed and working memory are a large factor in performance on the test, as is cognitive flexibility, a higher order executive skill. Trails B requires the individual to switch between two sequentially running sets and draw a line that connects, first, a number and then a letter beginning with 1 and then A. Impulsive errors that involve going from a number to a number despite being told to alternate between numbers and letters are often seen in individuals with brain injuries. Depression and other emotional conditions, as well as mild head injuries can have a slowing effect on Trails B. The main abilities assessed by Trails B are housed in the frontal lobe, such as complex attention as well as the inhibition required to not respond to irrelevant stimuli. When damage occurs in the frontal lobes, individuals have difficulty staying on task and are distracted by irrelevant stimuli. Individuals with frontal lobe injuries are unable to inhibit responses. The frontal lobes are responsible for the inhibition of responses and the preservation of goal-directed behavior (Luria, 1973). In completing the Trails B task, individuals are required to inhibit a response in order to alternate between the running sets of numbers and letters. Thus, errors occur when an individual displays cognitive inflexibility and is unable to inhibit a response and switch between the set of numbers and letters.

Processing speed is defined as the ability to process information quickly (Lichtenberger & Kaufman, 2013). It is thought to be a complex construct that plays a pivotal role in higher level cognitive functioning. Impairments in processing speed can result in impairment in other areas of cognitive abilities (O'Brien & Tulsky, 2008). Processing speed is typically measured by tasks of timed psychomotor tasks that reflect an individual's cognitive efficiency and ability to perform simple psychomotor tasks quickly and efficiently. The processing speed subtests of the WAIS-IV were designed to measure processing speed in a nonverbal format. The primary constructs assessed by the processing speed task of the WAIS are visual processing speed, motor processing speed, and visual-motor processing speed (Lichtenberger & Kaufman, 2013). There are additional constructs that influence performance on processing speed measures that include visual discrimination, visual attention, sustained attention, memory, and understanding instructions (Golden et al., 2000). These tests of processing speed are influenced by motor impairment, difficulties concentrating and understanding instructions, anxiety and depression, hyperactivity, motivation, fatigue, and low frustration tolerance (Golden et al., 2000). The WAIS-IV was designed to be a better measure of processing speed. Decreases in motor demands as well as a decrease in visual acuity were goals of the newest version of the WAIS, in order to make the test a purer measure of processing speed. Because Trails B has a strong processing speed component, it would be expected that subtests designed to be better measures of processing speed would be better predictors of performance on Trails B. The results of the analyses did not support the hypothesis.

The hypothesis was proposed because of the addition of Visual Puzzles to the test, which, while a related nonverbal measure of intelligence, adds to the WAIS-IV over and above Block Design and Matrix Reasoning in that it assesses more of an integrative frontal, executive process than both Block Design and Matrix Reasoning. With the inclusion of a timed component to puzzle manipulation and spatial reasoning, the integrative features of Visual Puzzles were proposed to influence more frontal lobe functions over and above the other nonverbal tests from the WAIS-III in that the task requires frontal skills of hypothesis formation, mental flexibility, planning, problem solving, and conceptualization. The task taps more of the frontal lobe functions that are assessed by Trails B as opposed to only the flexibility component that is more consistent with the untimed problem solving of Matrix Reasoning and timed in Block Design but where there is more emphasis on visuospatial reasoning and skills.

The frontal lobes possess a group of abilities known as the executive skills, include attention, reasoning, judgment, problem solving, creativity, emotional regulation, impulse control, and awareness of one’s functioning (Scott & Schoenberg, 2011). Luria (1973) discussed the simple to complex processes involved in higher order executive skills that are produced in the frontal lobes. According to Luria (1973), the frontal lobes are responsible for the regulation of complex intellectual processes and voluntary attention. Visuoconstruction, visual reasoning, and problem solving, as measured by Block Design and Matrix Reasoning, are some nonverbal abilities partially assessed by the frontal lobes. The perception of shapes as assessed in Block Design, Matrix Reasoning, and Visual Puzzles is an active process, which requires the individual to search for the most important elements of information, compare them, create a hypothesis concerning the meaning of the design as a whole, and then verify the hypothesis by comparing it with the original elements of the objects or designs seen.

Over and above these shared aspects of the three PRI subtests of the WAIS-IV, the new subtest addition of Visual Puzzles was designed to assess the more complex and integrated ability of executive skills that is more heavily influenced by frontal lobe functioning and requires the individual to develop and test hypotheses based on give rules under timed constraints. The integrated process taps frontal lobe functions in that an individual must test and develop hypotheses. Visual Puzzles, like Trails B, requires the individual to use cognitive flexibility and psychomotor speed. This program of analysis and synthesis requires switching from various operations and hypotheses, which can be disrupted with frontal lobe conditions (Luria, 1973). Individuals with frontal lobe conditions have difficulty switching and testing hypotheses and are easily distracted, making it difficult for them to perform the correct analysis and synthesis of material to generate and test hypotheses to complete the tasks. This produces inflexibility in the problem solving approach, as they are often unaware of their mistakes and unable to correct them (Luria, 1973). This is similar to the inflexibility observed with Trails B, when an individual is unable to shift between sets and both are mediated by the frontal lobes.

Based on this more integrative process as well as the more integrative process of the Trails B, it would be expected for the new subtest to add more predictive ability to the performance on Trails B over and above Block Design and Matrix Reasoning, which contain less integrated assessments of executive skills and are less frontal in nature and can be more spatially oriented. Despite these similarities and the focus towards a more integrated measure of frontal lobe functioning and executive abilities, the current analyses do not support the hypothesis. The Visual Puzzles subtests did not significantly add to the predictive model of the WAIS-IV over and above the WAIS-III predictive model.

Not only was the Visual Puzzles test expected to make the newest version of the WAIS more consistent with Trails B but the WAIS-IV was designed to be a stronger measure of working memory, which is another ability tapped by Trails B. Working memory is assessed by Trails B through the individual being required to mentally hold information and continue alternating sets of numbers and letters in sequential order. On the WAIS-III working memory is assessed through Digit Span, Arithmetic, and Letter Number Sequencing. For the WAIS-IV working memory is assessed through two subtests of Digit Span and Arithmetic. The WAIS-IV was designed to be a better measure of working memory (i.e., the ability to actively maintain information and mentally manipulate it in order to produce a result). Specifically, the Digit Span subtest was redesigned to decrease rhyming numbers and a sequencing portion was added that requires the individual to perform a more complex working memory task than the previous version of Digit Span that contained only forwards and backwards. The specific sequencing component would be expected to be more consistent with sequencing abilities tapped by Trails B. These changes are relevant to performance on Trails B, as parts of the test are strongly related to and directly require working memory skills to mentally hold two sets of sequential numbers and letters. Despite these changes that were proposed to make the test a better predictor of performance on Trails B, the current results show that the WAIS-IV was not a significantly better predictor of performance on Trails B than the WAIS-III.

While Visual Puzzles, Digit Span, and the PSI subtests and Trails B do tap similar abilities, the tests are not without their differences. Trails B is an integrated measure of the abilities assessed by the various measures of the WAIS-IV. Trails B is considered to be a good measure of cerebral dysfunction and contains more cognitive flexibility and set-shifting components. Like the new sequencing component of the Digit Span subtest, Trails B requires sequencing, but unlike Digit Span's sequencing component, Trails B requires shifting or alternating between a set of numbers and letters simultaneously as part of the sequencing component, as opposed to simply sequencing numbers. Thus, Trails B is a more difficult task. Trails B is presented in a visual format as opposed to auditory format, like Digit Span. In regards to the PSI subtests and Trails B, Trails B has less of a graphomotor component and fewer motor demands, as the task only requires drawing lines to numbers in sequential order as opposed to the transcription of symbols required for the WAIS-IV Coding subtest. Trails B has less of a visual discrimination and visual attention component than the WAIS-IV Symbol Search subtest, because the individual is only required to visually scan for numbers and letters as opposed to scanning and attending to differences in symbols that sometimes include only subtle differences. In regards to Visual Puzzles and Trails B, Trails B requires a graphomotor component and less of a demand for visuospatial skills. Trails B does not require visuospatial problem solving.

Further examination of the relationship between the two versions and Trails B revealed that there were no observed differences in the most significant predictors of

Trails B performance for the different versions of the WAIS, in that no subtest was able to significantly predict performance over and above the other subtests and age an education. The lack of differences are of interest because the changes to the WAIS-IV discussed earlier would be expected to show different predictive abilities of the subtests.

Pearson correlations were examined to further assess the relationship between the two versions of the WAIS and performance on Trails B. For the WAIS-III, all of the subtests had significant negative correlations with performance on Trails B, with the exceptions of Comprehension and Vocabulary. Thus, the correlation analyses indicate that as the raw scores for the subtests increased (i.e., performance improved) the amount of time to complete Trails B decreased, indicating better performance on Trails B.

The WAIS-III subtest most highly correlated with performance on Trails B was Symbol Search, Matrix Reasoning, Arithmetic, Letter Number Sequencing, Digit Span, Picture Completion, Digit Symbol Coding, Picture Arrangement, Block Design, Similarities, and Information. The Symbol Search subtest was the highest correlated subtest, which likely shows the relationship between processing and psychomotor speed used with both the subtest and Trails B. Matrix Reasoning was the second most highly correlated subtest with Trails B, indicating the cognitive flexibility required for both tasks. Matrix Reasoning requires cognitive flexibility in being able to formulate hypotheses and problem solve to find patterns in the stimuli provided, while Trails B requires cognitive flexibility in alternating between two running sets of numbers and letters. Arithmetic was the next most highly correlated WAIS-III subtest with Trails B, showing the use of working memory used for the subtest and Trails B and showing the relationship between working memory and processing speed as well as executive functions. The same is true for the next highest correlations of Letter Number Sequencing and Digit Span. Picture Completion's correlation with Trails B is likely due to the relationship of visual attention under timed constraints required for both measures. Digit Symbol Coding being one of the subtest less significantly correlated with Trails B performance was surprising considering the processing and psychomotor speed similarities of both tasks. The lower relationship could be due to the more complex psychomotor speed required for Digit Symbol Coding. Due to the nonverbal nature of Trails B, it would be expected for the verbal subtests of Similarities, Comprehension, Vocabulary, and Information to be less strongly correlated with performance on Trails B.

All of the subtests of the WAIS-IV had significant negative correlations with Trails B. Similar to the WAIS-III results, as performance time on Trails B increased raw scores on the subtests decreased. The results show that poorer performance on Trails B was indicative of poorer performance on the subtests of the WAIS-IV.

For the WAIS-IV, the highest correlated subtest was Coding, which was not surprising considering the processing and psychomotor components of each measure. The second most highly correlated WAIS-IV subtest with performance on Trails B was Arithmetic, which likely reflects the strong working memory and processing speed relationship, while showing the working memory component of Trails B required to mentally hold to different sequential sets of information. Visual Puzzles was the third most highly correlated subtest with performance on Trails B. The observed relationship shows the executive and frontal lobe abilities tapped by both Visual Puzzles and Trails B. The PSI subtest of Symbol Search was the fourth most highly correlated subtest with performance on Trails B. The relationship shows the visual attention, visual scanning, and processing and psychomotor speed required for each measure. Block Design was the next most highly correlated subtest with Trails B, indicating the psychomotor and flexibility required for each task as well as the motor components of the tests. Digit Span was the sixth most highly correlated subtest with Trails B performance. The observed relationship was expected to be higher, given the sequencing component added to the new version of the subtest that is similar to the sequencing component of Trails B. The lack of a stronger relationship to the subtest is likely due to the differences in the visual and auditory presentation differences as well as the fact that the sequencing component of the subtest that only makes up a third of the subtest. Similarities was the next most highly correlated subtest with performance on Trails B that could show the low relationship with verbal measures and Trails B. The verbal abstract reasoning involved in Similarities does have a relationship to the cognitive flexibility involved in Trails B. Matrix Reasoning was the eighth most highly correlated subtest with performance on Trails B, which was surprising that it was not higher considering that both test require a high amount of cognitive flexibility. The differences could show the differences in a timed and untimed test and the fact that Matrix Reasoning does not have a speeded component nor does it involve any motor abilities. Vocabulary and Information being the least correlated subtests with Trails B performance was not surprising considering that Trails B does not required verbal abilities.

The observed correlations show that, as would be anticipated, the processing and psychomotor speed and executive skills measures are strongly related to Trails B and higher order cognitive abilities such as cognitive flexibility. The correlations show that mental arithmetic (i.e., mental manipulation/working memory) are strongly related to executive abilities. Digit Span from the WAIS-III as well as Digit Span from the WAIS-IV were not as strongly correlated as might be expected, given the working memory component of the measures as well as the new sequencing component of the WAIS-IV Digit Span. The new sequencing component that was added to the WAIS-IV Digit Span subtest, as a proposed way to make a higher load working memory measure was expected to make the measure more consistent with Trails B that has a strong sequencing aspect. The results of the correlation analyses indicate that the sequencing component of the WAIS-IV Digit Span subtest did not add to the neuropsychological utility of the measure, in that the measure does not appear to be any more highly related to Trails B, which requires an amount of working memory abilities for a portion of the test, than the WAIS-III version with only forward and backward digit span. While the hypothesis was not supported, the order of significant correlations for the WAIS-IV shows that the changes to the WAIS-IV did result in closer relationships with the subtests proposed to measure fluid reasoning and a widely used neuropsychological measure of fluid reasoning. The processing speed subtest showed significant relationships with performance on Trails B, as would be expected considering the processing component.

Hypothesis 6

The sixth hypothesis stated that the subtests of the WAIS-IV would be better predictors of performance on the WCST, specifically in the number of perseverative errors, than would the WAIS-III. The changes to the WAIS-IV to make the measure more consistent with neuropsychological measures like executive abilities and processing speed and working memory were expected to make the WAIS-IV a better predictor of performance on the WCST than the WAIS-III. The hypothesis was not supported by the current analyses.

The WCST is a widely used neuropsychological measure that assesses executive functions, particularly problem-solving, abstraction, hypothesis generation and testing, learning, incorporating feedback, and set-shifting, all mediated by the frontal lobe. In addition, the measure involves other abilities like attention and concentration, which are required for the individual to keep track of the present category to which he/she is matching. To complete the task, the individual is asked to match a deck of cards with one of four stimulus cards without being told how to match the card. After attempting to match the card, the individual is told whether the match was correct or incorrect. The individual must incorporate the feedback received in order to make an attempt at finding the correct match for the next card in the deck. Performance on the WCST produces several scores, but the most consistent with frontal lobe issues is the perseverative errors score. Perseverative errors on the WCST are defined as an individual continuing with a certain category despite receiving feedback that the category is incorrect. A perseverative error is indicative of difficulties with set-shifting and cognitive flexibility as well as difficulties incorporating feedback. The frontal lobe mediates these activities, as individuals with frontal lobe difficulties often display perseverative errors and difficulty with cognitive flexibility. Individuals with frontal lobe damage may make little attempt to examine the conditions of the problems and, thus, attempt to problem solve impulsively, without a plan. These individuals do not compare their answers with the original conditions of the task and have do not incorporate feedback well, as they are not aware of the futility of their solution. These individuals may display impulsive guesses as opposed to true problem solving strategies (Luria, 1973).

Changes to the WAIS-IV were believed to make the test a better measure that would be more closely related to neuropsychological measures and theory. The WAIS-IV contains fewer time bonuses and fewer motor demands, which can negatively impact neurologically impaired individuals unnecessarily. The most significant change that was expected to yield significant changes in the prediction of performance on the WCST was the redesigning of subtests that was intended to produce a stronger association and perceived better measurement of fluid reasoning (i.e., ability to process/manipulate abstractions, rules, generalization, and logical relationships), which are strongly measured by the WCST and used in higher order cognitive processing and executive skills. Specifically, not only did the designers of the WAIS-IV strive to make the PRI subtests better measures of fluid reasoning by diminishing motor demands and timed bonuses, a new subtest (i.e., Visual Puzzles) was added to the WAIS core battery in order to be a better measure and make an overall better index measure of perceptual reasoning/fluid reasoning/intelligence. These changes were expected to yield a greater neuropsychological utility of the WAIS-IV because of the focus on underlying cognitive principles and fewer extraneous variables that can impact raw scores and the achieved intellectual scores.

The hypothesis was proposed because of the addition of Visual Puzzles to the test, which, while a related nonverbal measure of intelligence, adds to the WAIS-IV over and above Block Design and Matrix Reasoning in that it assesses more of an integrative frontal, executive process than both Block Design and Matrix Reasoning. With the inclusion of a timed component to puzzle manipulation and spatial reasoning, the integrative features of Visual Puzzles were proposed to influence more frontal lobe functions over and above the other nonverbal tests from the WAIS-III in that the task requires frontal skills of hypothesis formation, mental flexibility, planning, problem solving, and conceptualization. The task taps more of the frontal lobe functions that the WCST measures as opposed to simply the spatial relations of the WCST that are more consistent with Block Design and the untimed problem solving of Matrix Reasoning. Matrix Reasoning, like WCST contains an untimed problem solving component in order to complete the task. Thus, it would be expected to have a strong relationship with WCST performance, though it would not be expected to be as highly related as the more frontal task of Visual Puzzles.

The frontal lobe possesses a group of abilities known as the executive skills, which include attention, reasoning, judgment, problem solving, creativity, emotional regulation, impulse control, and awareness of one's functioning (Scott & Schoenberg, 2011). Luria (1973) discussed the simple to complex processes involved in higher order executive skills that are produced in the frontal lobes. According to Luria (1973), the frontal lobes are responsible for the regulation of complex intellectual processes and voluntary attention. Visuoconstruction, visual reasoning, and problem solving, as measured by Block Design and Matrix Reasoning, are some nonverbal abilities partially assessed by the frontal lobes. The perception of shapes as assessed in Block Design, Matrix Reasoning, and Visual Puzzles is an active process, which requires the individual to search for the most important elements of information, compare them, create a hypothesis concerning the meaning of the design as a whole, and then verify the hypothesis by comparing it with the original elements of the objects or designs seen.

Over and above these shared aspects of the three PRI subtests of the WAIS-IV, the new subtest addition of Visual Puzzles was designed to assess the more complex and integrated ability of executive skills that is more heavily influenced by frontal lobe functioning and requires the individual to develop and test hypotheses based on give rules under timed constraints. The test replaced the former subtest of Picture Completion of the WAIS-III, which was not as highly correlated with WCST performance or other executive measures and tended to rely more on visual attention. Visual Puzzles was expected to be a measure of integrated functional lobe functioning. The integrated process taps frontal lobe functions in that an individual must test and develop hypotheses. Individuals with frontal lobe conditions are more likely to exhibit impulsive, fragmentary guesses as opposed to intellectual activity and hypothesis testing required to adequately complete the activity with the given set of rules and criteria (Luria, 1973). Visual Puzzles, like WCST, requires the individual to understand the given material, formulate a hypothesis, and test the hypothesis with the given set of rules in order to evaluate the hypothesis and further resume solving problems. This program of analysis and synthesis requires switching from various hypotheses, which can be disrupted with frontal lobe conditions (Luria, 1973).

Individuals with frontal lobe conditions have difficulty switching and testing hypotheses and are easily distracted, making it difficult for them to perform the correct analysis of material to generate and test hypotheses to complete the tasks. This produces inflexibility in the problem solving approach, as they are often unaware of their mistakes and unable to correct them, even if told (Luria, 1973). When told of an incorrect performance, individuals may show perseveration and continue with the same approach even when told their approach is incorrect. The process of forming and executing a program is difficult for individuals with frontal lobe lesions, as they are unable to first analyze the component elements of the given conditions, formulate a definite strategy and then compare the results with the original conditions given in both the Visual Puzzles subtest and the WCST. For less complex tests with simple and unambiguous solutions, these individuals may not show significant difficulties (e.g., Matrix Reasoning and Block Design), as the process is not as complex and the approach not as integrated as that seen with Visual Puzzles and the WCST.

Based on this more integrative process as well as the more integrative process of the WCST task, it would be expected for the new subtest to add more predictive ability to the performance on the WCST over and above Block Design and Matrix Reasoning, which contain less integrated assessments of executive skills and are less frontal in nature and more spatially oriented. Despite these similarities and the focus towards a more integrated measure of frontal lobe functioning and executive abilities, the current analyses do not support the hypothesis. The Visual Puzzles subtests did not significantly add to the predictive ability of the WAIS-IV over and above the WAIS-III nonverbal subtests.

While Visual Puzzles and the WCST do tap similar integrative abilities, the two tests are not without their differences. The WCST contains multiple components that assess concept formation, hypothesis testing, and sustained attention without the timed component of Visual Puzzles and while the individual receives direct feedback regarding his/her performance. Perseveration and the ability to incorporate feedback are more heavily assessed by WCST. These components set the test apart from Visual Puzzles and the other PRI subtests that assess an integrated process of hypothesis testing and problem solving with puzzles, as measured by the other PRI subtests of Block Design and Matrix Reasoning.

Further examination of the relationship between the two versions and the WCST revealed that there were observed differences in the most significant predictors of WCST performance for the different versions of the WAIS. For the WAIS-III, no individual subtest was a significant predictor of performance on the WCST over and above the other subtests and age and education. For the WAIS-IV, the Matrix Reasoning subtest was able to significantly predict performance on the WCST over and above the other subtests and age and education. This finding makes sense, considering that the WCST and Matrix Reasoning share components in that both assess problem solving and hypothesis generation and testing. The changes in the Matrix Reasoning subtest from the WAIS-III to the WAIS-IV involved clearer teaching and instructions and fewer types of problems presented with clearer teaching instructions.

Pearson correlations were examined to further assess the relationship between the two versions of the WAIS and performance on WCST. For the WAIS-III, all of the subtests had significant negative correlations with performance on WCST, indicating that as the raw scores for the subtests increased the number of perseverative errors on the WCST decreased. Thus, better performance on the WCST resulted in better performance on WAIS-III subtests.

The WAIS-III subtest most highly correlated with performance on WCST was Matrix Reasoning, which was not surprising considering the nonverbal nature of the test and the problem solving, hypothesis testing, and cognitive flexibility tapped by both subtests. Picture Arrangement was the next most highly correlated measure, which involves nonverbal problem solving, hypothesis testing, cognitive flexibility, and abstract reasoning. This is similar to the WCST that involves nonverbal problem solving, cognitive flexibility, abstract reasoning and hypothesis testing. Digit Symbol Coding was the third most highly correlated subtest with WCST performance, which was surprising considering the perceived lack of processing speed involved in the untimed WCST measure. The observed relationship may show that the visual attention involved in both tasks. The next most highly correlated subtest with WCST was Block Design, which shows the nonverbal reasoning involved with both measures. The remaining correlations were in the following order Symbol Search, Letter Number Sequencing, Information, Similarities, Picture Completion, Arithmetic, Digit Span, Vocabulary, and Comprehension. The order was not surprising, particularly with the verbal subtests being less correlated with WCST, as the measure does not heavily assess verbal abilities.

For the WAIS-IV, all of the subtests had significant negative correlations with performance on the WCST, with the exception of Information that showed a non-significant negative correlation. Similar to the WAIS-III correlations, as performance improved on the WCST and fewer perseverative errors were committed, performance on WAIS-IV subtests increased.

The highest correlated subtest was Matrix Reasoning, Symbol Search, Coding, Block Design, Visual Puzzles, Similarities, Arithmetic, Digit Span, and Vocabulary. The Matrix Reasoning subtest being the most highly correlated with performance on the WCST was not surprising as both measures tap nonverbal reasoning, cognitive flexibility, and hypothesis generation and testing. The second and third most highly correlated subtests with performance on the WCST were the two subtests of the PSI (i.e., Symbol

Search, Coding) of the WAIS-IV. While this was an unexpected finding, it likely shows the visual attention components of the three tasks as well as the role processing speed may play in executive abilities and cognitive functioning. The fourth and fifth most highly correlated tests were the remaining two subtests of the PRI of Block Design and Visual Puzzles. These are not surprising considering that the WCST assesses nonverbal reasoning, hypothesis testing, and cognitive flexibility. It would be expected that the two tests would be more highly correlated with WCST performance than the PSI subtests. The timed component of both tests and the motor component of Block Design could explain why the relationship was not higher. It was expected that the Visual Puzzles subtest would bare a stronger relationship with performance on the WCST due to the frontal and executive components of the subtest. The final correlations with performance on the WCST involve the verbal subtests and the working memory subtest of the WAIS-IV. The nonverbal nature of the test makes it unsurprising that the verbal subtests are not strongly correlated with performance on the WCST. The strongest relationship between the verbal subtests and the WCST was with Similarities, which makes since considering that the subtest requires verbal abstract reasoning. The lower correlations with the WCST and the working memory measures are not surprising, considering that the WCST does not strongly assess working memory.

The observed differences in the correlations show that, as would be anticipated, the fluid reasoning and executive skills measures are strongly related to the WCST and higher order cognitive abilities such as problem solving, hypothesis testing, reasoning, and pattern finding. Specifically, it was evident that the Matrix Reasoning subtest taps similar abilities to the WCST performance, as the subtest had the strongest correlation between both the WAIS-III and WAIS-IV. Additionally, the correlations show that processing speed measures are strongly related to executive abilities. While the hypothesis was not supported, the order of significant correlations for the WAIS-IV shows that the changes to the WAIS-IV did result in closer relationships with the subtests proposed to measure fluid reasoning and a widely used neuropsychological measure of fluid reasoning.

With the changes to the WAIS-IV, it was be expected that the PRI subtests of Block Design, Matrix Reasoning, and Visual Puzzles would be more highly correlated with the WCST than the WAIS-III subtests of Block Design, Matrix Reasoning, and Picture Completion. The results of the Pearson correlation comparisons showed that there was not a substantial difference in the correlations between the PRI subtests of the WAIS-IV and performance on the WCST than the nonverbal subtests of the WAIS-III, despite the proposed changes to make the subtests more consistent with fluid reasoning, frontal lobe functioning.

Conclusions

The current study sought to examine the WAIS-IV and how the changes to the new version may impact the measure's usefulness in neuropsychological evaluations. The WAIS-IV included changes to some and the elimination of other subtests along with two new subtests (one core and one supplemental subtest). The two new subtests of Visual Puzzles and Figure Weights, an optional subtest, are part of the PRI. The WAIS-IV, with only 10 subtests, is significantly shorter than the WAIS-III, with 13 subtests (Hartman, 2009). The WAIS-IV aimed to be a better measure of fluid reasoning, processing speed, and working memory, while lowering the emphasis of speeded responses and on motor demands (Lichtenberger & Kaufman, 2013).

Earlier versions of the WAIS have been shown to have a significant relationship between their scores and neuropsychological measures (Zarantonello, 1988). It has been hypothesized that the more recent versions of the WAIS are more consistent with theory and research and are more useful clinically than their predecessors (Gottfredson & Saklofske, 2009). These changes support the need for the current research examining the WAIS-IV's predictive ability of neuropsychological measures and assessing the measure's utility in neuropsychological evaluations.

To examine the differences between the WAIS-III and the WAIS-IV, the subtests that make up the index scores for the WAIS-III (i.e., all subtests except Object Assembly) were entered into a hierarchical regression model after age and education were entered into the first block. The same was done for the core subtests of the WAIS-IV. The overall WAIS-III models were significant for all measures except FTT dominant and FTT non-dominant. The overall WAIS-IV models were significant for all neuropsychological measures.

When compared, no statistically significant differences were seen between the R^2 of the WAIS-III and the R^2 of the WAIS-IV regressions for the neuropsychological measures. There were differences in the subtests that accounted for a significant amount of variance in WAIS-III and WAIS-IV models, specifically for Trails A, WCST, and the Category Test. For Trails A, the Coding subtest was able to account for a significant amount of variance over and above the other subtests and age and education. This shows that the attempts to make the WAIS-IV a better measure of processing speed were likely achieved, at least for the Coding subtest. This was not the case for Symbol Search, which did not significantly predict performance. For the WCST, the WAIS-IV subtest of Matrix Reasoning was able to account for a significant amount of variance in the model over and above the other variables in the model. This indicates that the measure was a better measure of problem solving and may better assess the use of rules in reasoning than the Matrix Reasoning subtest on the WAIS-III. The findings of a stronger relationship with Matrix Reasoning and WCST are consistent with previous research that has shown that Matrix Reasoning was strongly related to executive skills (Dugbartey et al., 1999). Previous research has shown that WCST performance reflected sequential skills, which are prominent in assessing patterns seen in Matrix Reasoning (Golden et al., 1998). The stronger relationship with WAIS-IV Matrix Reasoning compared to WAIS-III Matrix Reasoning could be due to the subtest being reduced to only two types of problems on the WAIS-IV as opposed to 4 types of problems on the WAIS-III. There are more sequential problems on the subtest. Both Matrix Reasoning and the WCST have shown relationships with verbal analyses (Dugbartey et al., 1999; Golden et al., 1998).

For the Category Test, the WAIS-III subtest of Arithmetic was able to account for a significant amount of the variance over and above the other variables in the model. For the WAIS-IV, Coding was a significant predictor of performance on the Category Test. The WAIS-III Arithmetic subtest predicting performance on the Category Test shows the relationship between working memory and calculations used for both measures. The WAIS-IV subtest of Coding being a better predictor of Category performance shows the relationship between processing speed and visual discrimination of the measures. The finding coincides with other research that has shown a relationship between Coding and executive functioning measures (Davis & Pierson, 2012).

Based on the statistical comparison of the WAIS-III and WAIS-IV models, it appears that, despite efforts to make the test more consistent with neuropsychological measures and theory, the WAIS-IV does not provide substantially better clinical utility in neuropsychological evaluations over the WAIS-III. The WAIS-IV does appear to have achieved the task of fewer motor demands on some tasks (i.e., Symbol Search), while not on others (i.e., Coding). Symbol Search showed less of a relationship with motor speed, as measured by the FTT, from the WAIS-III to the WAIS-IV. It appears that, in an effort to decrease motor demands, the Symbol Search subtest does not account for a significant amount of variance on a neuropsychological measure of processing speed and was surpassed by the Coding subtest, which was shown to be more closely related to performance on Trails A but contained a stronger speeded motor component than Symbol Search.

In regards to the goal of the publishers of the WAIS-IV to decrease motor demands on all motor related tests, the WAIS-IV did not appear to decrease motor demands on the Coding subtest, as the correlations changed very little from the WAIS-III to the WAIS-IV. From the WAIS-III to the WAIS-IV, Digit Symbol Coding and Coding had significant and strong relationships with motor speed. In contrast, Symbol Search did show a decrease, while not significant, in correlations from WAIS-III to WAIS-IV in both motor speed measures. Block Design maintained a similar relationship to motor speed measures from WAIS-III to WAIS-IV.

It appears that the attempt to make the WAIS-IV a better measure of fluid reasoning and frontal lobe abilities was not accomplished. The Visual Puzzles subtest was not a better predictor of performance on more traditional neuropsychological measures of frontal lobe functioning and executive measures, as it did not significantly predict performance on any measure nor did Visual Puzzles add enough to make the overall models significantly better predictors of performance than the WAIS-III overall models. The finding is supported by Taub and Benson (2013) who found that the WAIS-IV was not a better measure of fluid reasoning than the WAIS-III.

The WAIS-IV model was not a significantly better predictor of working memory than the WAIS-III model. As previous research has shown, Trails B (Sanchez-Cubillo et al., 2009), Trails A (Mahurin et al., 2006), and Category (Golden et al., 1998) to be correlated with or related to working memory measures, it would be expected that the WAIS-IV working memory measures would be more strongly related to these neuropsychological measures. The overall regression models of the WAIS-III and WAIS-IV show that, for the Category Test, Arithmetic was significant for the WAIS-III and not the WAIS-IV, indicating a weaker relationship on the WAIS-IV and working memory. It appears that the sequencing component added to the WAIS-IV Digit Span subtest did not make the measure more consistent with neuropsychological measures of working memory, like Trails A and Trails B that require mental sequencing skills. The finding appears to contradict findings of Taub and Benson (2013) who found that the WAIS-IV provided a better measure of working memory than the WAIS-III.

The WAIS-IV was not a significantly better predictor of processing speed across the two PSI subtests than the WAIS-III. For Trails A, the WAIS-IV subtest of Coding was able to significantly account for the variance over and above the other variables in the model, while this was not observed for the WAIS-III. The overall models were not statistically different in the predictive abilities. Symbol Search did not account for a significant portion of the variance in either model. Correlation analyses for both versions of the WAIS did not show significant differences between Symbol Search and Coding and Trails A performance. For the WAIS-III, Symbol Search and then Digit Symbol Coding were the most strongly correlated subtests with performance on Trails A. While for the WAIS-IV, Coding and then Symbol Search were the most highly correlated subtests with performance on Trails A. It would appear that the changes to the Coding subtest of the WAIS-IV resulted in a slightly better measure of processing speed. The results of these analyses show that, despite these changes and a stronger relationship of the Coding subtest, the WAIS-IV, overall, was not a significantly better measure of processing speed over the WAIS-III. The finding contradicts findings of Taub and Benson (2013) who found that the WAIS-IV provided a better measure of processing speed than the WAIS-III.

Visual Puzzles and Neuropsychological Measures

It should be noted that the Visual Puzzles subtest did appear to add to the measured relationship with several neuropsychological measures over many of the subtests on the WAIS-III. The Visual Puzzles subtests were consistently the highest correlated PRI measure of the WAIS-IV subtests with all of the neuropsychological measures, with the exception of the WCST. Visual Puzzles had the highest correlation of the WAIS-IV subtests with performance on the Category Test, FTT dominant hand, and FTT non-dominant hand. The finding shows that Visual Puzzles was strongly related to frontal lobe functions and reaction time. It would appear that the timed component of the subtest plays a large role in performance on the task. Further examination of the relationship between the FTT dominant hand and non-dominant hand should be examined as this was an unexpected finding based on the fact that Visual Puzzles was designed as a non-motoric task.

Due to Visual Puzzles being the highest correlated PRI subtest with performance on Trails A and Trails B, it would appear that processing speed and cognitive flexibility are tapped by the new subtest. The findings of the current analyses coincide with the findings of Fallows and Hilsabeck (2012), who found that Visual Puzzles performance correlated with visuospatial reasoning, mental flexibility, and processing speed. Fallows and Hilsabeck (2012) found that Visual Puzzles was significantly correlated with performance on Trails A and Trails B but not WCST perseverative errors. The current research shows a significant correlation between WCST perseverative errors and Visual Puzzles, but this was the only neuropsychological measure where Visual Puzzles was not the most highly correlated PRI measure. For the WCST, Visual Puzzles was the lowest correlated PRI subtest. The correlation was significant, which would be expected considering that both tap problem solving abilities. The current study upholds the findings of Fallows and Hilsabeck (2012) that, despite the assertions of the creators of the subtest, Visual Puzzles is not a pure measure of nonverbal reasoning because the subtest assesses other abilities of mental flexibility, processing speed and reaction time, and visuospatial reasoning.

Limitations

There are several limitations of the present research that could limit the applicability of the results across settings. One of the limitations of the current research involves the potential practice effects of taking both the WAIS-III and WAIS-IV versions of the intellectual measure. A portion of the data came from an archival dataset. There was no way to control for the order of tests given and whether or not the WAIS-IV was given first, as done with the non-archival portion of the data collected. The WAIS-IV was generally given as the first test in the battery, with the WAIS-III being the final test in the battery. Since the tests were given as part of a larger neuropsychological battery, the time between the administration of the WAIS-IV and WAIS-III varied from as much as a few days to as much as several months. Previous research has shown that individuals, especially those of average and high average intelligence, a benefit from prior exposure on previous versions of the WAIS when the test was administered again two weeks later (Rapport et al., 1997). No research is currently available examining practice effects on the WAIS-III when previously exposed to the WAIS-IV. Practice effects could play a role in performance and the raw scores achieved on the subtests but to what extent is not determined, due to changes within subtests and subtest items from one version to the next.

Another weakness of the current research has to do with the population being pulled from a university clinic sample and research volunteers, with a mixed sample of healthy volunteers and clinically referred individuals with various diagnoses. Having a substantial portion of volunteers with no diagnoses, many who were college students, led to slightly higher than average IQ scores (WAIS-III FSIQ M = 106; WAIS-IV FSIQ M = 103) and could have influenced the results and performances. There could be less variation in abilities across the mixed sample. The mixed sample of individuals referred to the outpatient clinic of a university and healthy volunteers could make the results less generalizable to other settings, such as private practice facilities or hospital settings.

In the completion of the neuropsychological assessments, individuals provided background information regarding diagnoses and physical and mental health. Only general information was included in the databases. It may have been helpful to know more about each individual's medical history, medications at the time of testing, and severity of psychiatric illness or neurological conditions at the time of testing, specifically anything that may have impacted performance on cognitive assessments. The findings of the current research may be more generalizable, if this information had been available for analyses.

Another limitation of the current study involved the small sample size of individuals who had taken a battery with both the WAIS-III and the WAIS-IV. A total sample of 91 adults was used in the analyses. When the small sample size is coupled with a large number of predictors in a multiple regression, the squared multiple correlation coefficients can become unstable. Maxwell (2000) discusses the many rules of thumb that are used in deciding appropriate sample sizes to conduct a multiple regression. Some of the various rules of thumb discussed include the recommendation that with a moderate number of predictors a sample size of 300 to 400 individuals is needed for a multiple regression and the recommendation that the ratio of subjects to predictors should be at least 10 to 1. No matter which rule of thumb is considered, the current study's sample size of 91 participants with 12 and 15 predictors in the multiple regression models does not meet the suggested rules. The R^2 will increase with the addition of each predictor in the model (Maxwell, 2000). The differences seen between the squared multiple correlation coefficients in the current study should be interpreted with caution. The WAIS-III group had 15 predictors but the WAIS-IV group had only 12 predictors included in the model. Because of the smaller sample size and the larger number of predictors in the WAIS-III model, it may be that the squared multiple correlation coefficients seen are inflated due to the higher number of predictors and not to actual predictive ability of the WAIS-III.

The model used to compare the squared multiple correlation coefficients in the current study was proposed by Alf and Graf (1999) as a way to test the significance of differences observed in multiple correlation coefficients between two dependent groups. Alf and Graf (1999) modified the Olkin and Finn (1995) models, in order to simplify the method and reduce the complexity of the calculations. Olkin and Finn (1995) recommend that the method be used with caution in moderate sample sizes (e.g., $60 < n < 200$) but can be readily used with larger sample sizes. In the current study the sample sizes fall within the suggested size for careful use of the method. Algina and Keselman (1999) suggested that the model could be used reliably with smaller sample sizes but warned that as k, the number of predictors, increased larger sample sizes would be needed to control the coverage probability. Alf and Graf (1999) demonstrated that the approach could be used with dependent samples. The samples used were large, much larger than the sample in the current study. The current study does meet the sample size requirements, but has a high number of predictors used in the models, with a smaller sample size than that used by Alf and Graf (1999). As a result, conclusions based on the model comparing the squared multiple correlation coefficients should be made cautiously.

Implications for Future Research

For future studies, the literature would benefit from an expansion of the current study using much larger sample sizes to get an examination of the differences in the predictive ability of the WAIS-III and WAIS-IV on neuropsychological measures.

According to Johnstone et al. (1997) and Loring and Bauer (2010), the WAIS is one of the most commonly used intelligence scales. Understanding the clinical utility of the newest version of the WAIS is important for neuropsychologists who will be implementing the use of the measure in their standard test batteries. Previous versions of the WAIS have been shown to correlate with and predict performance on neuropsychological measures (Berger, 1998; Devaraju-Backhaus et al., 2001; Dugbartey et al., 1999; Golden et al., 1998; Johnstone et al., 1997; Sanchez-Cubillo et al., 2009; Titus et al., 2002). Loring and Bauer (2010) explain that because of the changes to the content of the scales and subtests, there could be problems with an inaccurate diagnosis or classification of individuals if processes or rules developed using the earlier versions of the WAIS are used with the WAIS-IV. Understanding the full neuropsychological utility of the WAIS-IV is important and future studies could replicate studies conducted with the WAIS-III to examine whether the same findings hold true for the WAIS-IV.

The WAIS-IV contains a new core subtest of Visual Puzzles. The current study found that the Visual Puzzles subtest was significantly correlated with all of the neuropsychological measures used in the current analyses. While a test similar to Visual Puzzles (i.e., Spatial Relations) exists on the Woodcock-Johnson III Tests of Cognitive Abilities and is said to assess manipulation of visual images and visual-spatial thinking, it will be important for future research to examine the usefulness of the version presented on the WAIS-IV and how it contributes to the PRI and the FSIQ. Due to the relationship shown between Visual Puzzles and motor measures, further examination of potential causes for the observed relationship would be beneficial, as the test is purported to be a non-motoric task.

It will be important to understand the relationship between Visual Puzzles and other neuropsychological measures. The literature would benefit from studies evaluating Visual Puzzles' relationship to other neuropsychological measures not evaluated in the current study. These, some as suggested by Fallows and Hilsabeck (2012), could include the Judgment of Line Orientation (Benton, Sivan, Hamster, Varney, & Spreen, 1994), Hooper Visual Organization Test (Hooper, 1958), and Visual Form Discrimination Test (Benton et al, 1994) as well as Rey-Osterrieth Complex Figure Test (Meyers & Meyers, 1995). Since research has shown potential verbal components assessed by Visual Puzzles (McCrea & Robinson, 2011), it would be helpful to further assess the subtest's relationship with measures of verbal abilities.

While it would be helpful for clinicians to understand the relationship between Visual Puzzles and these other neuropsychological measures to assess the utility of the subtest and what the subtest measures, it would be helpful to fully assess the entire WAIS-IV and its relationship with other widely used neuropsychological measures to further asses the entire tests clinical utility. This could include examining various memory measures commonly used in neuropsychological batteries and the WAIS-IV.

It would be beneficial for future research to examine the supplemental subtests of the WAIS-IV and neuropsychological measures. While it was beyond the scope of the current research, examining the utility of the new subtest of Figure Weights could be helpful. The new subtest is hypothesized to add to the fluid reasoning measured by the WAIS-IV and research is needed to verify the utility of the task in neuropsychological batteries.

The current study consisted of individuals with various psychiatric and neurological conditions as well as healthy volunteers. Future research would be wise to examine specific populations to evaluate the types of WAIS-IV profiles that are seen in specific conditions. Currently, there is little in the published literature examining the WAIS-IV in neuropsychological cases. It is yet to be seen how the four index scores will add to neuropsychological evaluations of an individual. Loring and Bauer (2010) explain that it is too early to say that the VCI and the PRI are comparable to the Performance IQ and Verbal IQ. The VCI and the PRI may be less sensitive to non-focal brain impairment than the Performance IQ and the Verbal IQ because of more narrowed composite scores and less sensitivity to psychomotor slowing due to a decrease in emphasis on speeded performance (Loring & Bauer, 2010). Therefore, it is important that future studies examine the utility of the WAIS-IV with various populations and the types of profiles seen in specific populations.

Summary

In conclusion, while the hypotheses of the current study were not supported, the results provide meaningful additions to the limited literature examining the newest version of the WAIS. Despite seeing little difference in the two versions of the test in regards to predictive ability on the neuropsychological measures, the WAIS-IV continues to show strong relationships with neuropsychological measures as has been found with earlier versions of the WAIS (Johnstone et al., 1997; Berger, 1998; Sherman et al., 1995; Golden et al. 1998; Sanchez-Cubillo, 2009; Dugbartey et al., 1999; Titus et al., 2002; Devarju-Backhaus et al., 2001). While no significant changes in the predictive ability were seen between the WAIS-III and WAIS-IV, it should not be concluded that the WAIS-IV is of no improvement over the WAIS-III.

Hartman (2009) explains that the WAIS-IV was designed to mirror theoretical changes in the field and strengthen the test's developmental appropriateness, user friendliness, and clinical utility. With only 10 subtests and lower discontinue rules, the WAIS-IV is significantly shorter than the WAIS-III (Hartman, 2009). Loring and Bauer (2010) discuss the move away from global IQ scores like those used with the WAIS-III to composite scores as with the WAIS-IV, explaining that index scores are a more useful way to assess differential diagnoses. The WAIS-IV provides four indices that make up FSIQ and coincide more with the theoretical framework of multiple factors making up intelligence rather than the two factors of FSIQ on the earlier versions of the WAIS. In the current study, little significant difference was seen between the WAIS-III and WAIS-IV in terms of predictive ability for neuropsychological measures. The findings of the current study may indicate that the WAIS-IV may not be a vast improvement in regards to neuropsychological utility over the WAIS-III, but the shorter administration time and movement towards consistency with current theoretical models of intelligence are substantial advances from the previous versions.

Despite the WAIS-IV not being a significantly better predictor of performance on neuropsychological measures over the WAIS-III, the new version of the test is useful in neuropsychological batteries because the test assesses a range of abilities with a strong standardization (Lezack, Howieson, Loring, Hannay, & Fischer, 2004). The current research shows that the subtests of the WAIS-IV are related to neuropsychological measures and may help in the interpretation and assessment of these abilities. While the WAIS is considered the gold standard for intellectual assessments and is included in most neuropsychological batteries, the newer version does not appear to add significantly to the clinical utility over the WAIS-III. It is important that clinicians use the subtests in conjunction with neuropsychological measures, as the current research shows the relationships between subtests and measures are not perfect and there could be danger in over interpreting the subtests and index scores if only the WAIS-IV is used to assess working memory, frontal skills, and processing speed.

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